HANDBOOK OF HYGIENE

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THIS HANDBOOK

IS

RESPECTFULLY DEDICATED

TO

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PREFACE.

There is no need that I should say much by way of preface. I believed that such a handbook would be required after the passing of the Public Health Act 1872, and I have endeavoured to supply the want.

Amongst the numerous works which I have consulted, I desire especially to mention Dr. Parkes' work on Practical Hygiene; Mr. Simon's Reports to the Privy Council; Dr. Letheby's work on Food; Captain Douglas Galton's work on the Construction of Hospitals; and the writings of Dr. Angus Smith, Dr. Hassall, Mr. Rawlinson, Mr. Eassie, and Professor Rankine. Full acknowledgment of other authors is given in the proper places.

I have occasionally inserted extracts of reports to show how sanitary inquiries should be conducted and reports written, nor have I hesitated to use quotations when such quotations bear the stamp of authority.

In Appendix I., I have given an excerpt of the various sanitary enactments, or parts of them, which more immediately concern the duties of medical officers

of health; and in Appendix II., I have added a price-list of analytical apparatus and reagents referred to in different portions of the work. It will be seen that, as regards food and water, I have only dealt with qualitative examination, so that those who are desirous of becoming proficient in quantitative analysis as well should procure Dr. Parkes' Manual.

While I have endeavoured to notice briefly all the points which are of importance to medical officers of health, I have so arranged the work that it may prove useful as a text-book to medical students, and as a handy book to medical practitioners generally. To all those outside the profession who are interested in sanitary matters, and who may care to read the work, I may at least say that it contains some amount of information freed from technicalities and worth knowing.

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CHAPTER I.—INTRODUCTORY.

PUBLIC HEALTH AND PREVENTABLE DISEASE.

Public Hygiene may be defined as that branch of sanitary science which concerns the physical condition of communities. It embraces a consideration of the various influences operating upon society, whether for its material good or its actual deterioration, with the view of extending the former, and preventing, or ameliorating, as far as possible, the effects of the latter. It involves the enactment of laws by which the safety of the whole may be protected against the errors of a part, and, above all, it aims at the prevention of disease by the removal of its avoidable causes. In a wide sense, therefore, the science of public hygiene enlists the services of the people themselves in continuous efforts at self-improvement; of the teachers of the people, to inculcate the best rules of life and action; of physicians, in preventing as well as curing disease; and of lawgivers, to legalise and enforce measures of health-preservation. But while it is the special province of the medical profession, as guardians of the public health, to study the causes of physical deterioration and disease, and to point out how far these causes may be controlled or averted, the general well-being of the people must mainly depend on their own exertions and self-restraint.

Sanitary improvements in man's material surroundings will not compensate for social transgressions against laws of morality; for public virtue is essential to public health, and both to national prosperity.

The time, however, has gone by when people can be dragooned into cleanliness or be made virtuous by police regulations, and hence it is that the most thoughtful among practical reformers of the present day base their hopes of sanitary progress on the education of the masses as the real groundwork of national health. The people must be taught that good conduct, personal cleanliness, and the avoidance of all excesses, are the first principles of health-preservation; that mental and physical training must go hand in hand in the rearing and guidance of youth; and that morality does not consist so much in a blind observance of the formulas of empty creeds as in a hearty submission to precepts of health. Nor is this all. They must be interested systematically in the general results of sanitary progress, and become more intimately acquainted with the social and material causes by which it is impeded. Unless a knowledge of these fundamental principles of hygiene be widely disseminated amongst them, it is in vain to expect that legislative enactments, however well devised, will succeed in raising the standard of public health to any considerable extent.

If it be objected that such knowledge cannot be imparted in schools, it may at all events be conveyed through the public press and from the pulpit; or is it too much to hope that the wordy warfare concerning the origin of human life may speedily give place to united efforts in striving to prevent its appalling waste?

Taking, then, this wide view of the scope of public hygiene, the subject of public health and preventable disease may be briefly discussed under the following sections :—

I. Hereditary Influence.
II. Causes of Deterioration and Disease.
III. Preventable Disease.

Section I.—Hereditary Influence.

Although there are many biologists who do not accept the Darwinian theory of "Pangenesis" in its entirety, there are few amongst them who dispute the influence of heredity which it serves so fully to explain. As regards the individual, the term heredity is the expression of the fact that a man is wholly built up of his own and ancestral peculiarities, and so far as these are concerned, it matters little or nothing what were the characteristics of the early progenitors of his race. In other words, the accumulation of individual variations through recent descent has a far greater influence upon a man's bodily and mental constitution than the unchanged gifts of a remote ancestry, so much so, indeed, that these latter may be regarded as a vanishing quantity. This result of the Darwinian theory has been conclusively demonstrated by Mr. Galton in his work on *Hereditary Genius*, and it is especially valuable as affording a clear and succinct conception of the influence of heredity in all cases in which individual variations lie well within the limits of stability of a race.

According to this view, the progeny is invariably moulded by the characteristics of its more recent ancestry, and by those of the parents more than by those of its grand-parents, and so on backwards in a constantly

decreasing ratio. It also tends to show that *personal* characteristics or peculiarities, however much they may apparently differ from those of immediate progenitors, are not so independent as might at first sight be supposed; that they are, in reality, modified "segregations" of what already existed, either partly or wholly, in a latent condition.

But without pursuing the subject too far into the regions of controversy, it will suffice for the present purpose to adduce some of the more important opinions which are entertained by leading biologists concerning the influence of heredity, alike on body and mind, in health and disease. These may be summarised as follows:—

1. The influence of both parents on the bodily constitution of the offspring is manifested in personal resemblances, such as, stature, similarity of features, walk, gesture, colour of hair, etc. Some of the children may bear a greater resemblance to the father, others to the mother; but it is rare to meet with any instances in which some distinctive characteristics of both parents cannot be traced.

2. The influence of the other more immediate progenitors on the bodily constitution of the offspring is manifested by the resemblances which constitute the phenomenon known as atavism, which may be explained in this way:—A man, for example, does not inherit all the characteristics of either his father or his mother, and of those which he does inherit, only some are developed, whilst others remain latent, and are probably developed in a brother or sister. His son, however, may in turn inherit the same characteristics, but with this difference that those which were latent in the

father become fully developed in him, so that he comes to bear a stronger resemblance to a grand-parent or some other relative, as an uncle or aunt, than to his father or mother.—(*A Physician's Problems*, by Dr. Elam.)

3. The influence of race, or special type, in heredity, is manifested by the constancy of averages, under tolerably constant conditions, from generation to generation, and this not only as regards the whole body and its various component parts, but also as regards all the facts which are comprised in the wide range of social and vital statistics.

4. Deviations from these averages or from the normal type, although they are transmissible, cannot transcend certain limits. Thus, as regards size, the giant and dwarf form the extreme links of the chain; and hence, in the procreation of individuals representing these deviations, the tendency to revert to the normal type is invariably manifested in the offspring.

5. As all forms of deterioration or disease may be regarded as deviations, or perverted life-processes, they are likewise subject to limitation in transmission, and there is the same tendency exhibited to revert to normal type under improved conditions. Thus, all chronic diseases appear to be transmissible, either as a morbid tendency or in their general form, such diseased heritage being well exemplified in the case of gout, scrofula, phthisis, syphilis, and insanity; but, by adopting suitable measures, the disease may be finally eradicated from the family, or the morbid tendency be overcome. It has also to be remembered that a hereditary disease or a morbid tendency may remain latent, like any other characteristic, for one or two generations, and become developed in the next.

6. Mental and moral qualities, if indeed they can be separated, are subject to the same law of heredity as other personal characteristics, with this important addition, that any vicious habit or tendency in the parents becomes, as a rule, intensified in some form or other in the offspring. With regard to mental capacity, Mr. Galton has clearly demonstrated, in the work already referred to, "that a man's natural abilities are derived from inheritance, under exactly the same limitations as are the form and physical features of the whole organic world;" and Herbert Spencer, Morel, Dr. Maudsley, and many others, uphold that a man's mental *incapacity* is similarly conditioned,—that perversion or absence of the moral sense is, in effect, as much a portion of some men's inheritance as their height or weight. In no class of persons is the truth of this doctrine better exemplified than amongst habitual criminals;—their strong impulses and feeble wills, their vicious propensities and absence of moral sense, which constitute the fate of their heritage, render them more or less irresponsible members of society.

7. Any particular characteristic, especially if it be of the nature of a deterioration or taint, when common to both parents, is liable to be intensified in the offspring. It is on this account that marriages between blood-relations are inadvisable, inasmuch as latent morbid tendencies, should they form part of the organic patrimony of the family, are almost certain to become developed in the children.

8. It would appear that the characteristics of the offspring not only depend upon the habitual conditions of the parents, but also upon the condition in which they may be at the time of sexual congress. Hence,

the offspring of parents usually healthy and temperate, if begotten in a fit of intoxication on both sides, may be born imbecile. In the words of Dr. Maudsley—"Here, as elsewhere in nature, like produces like; and the parent who makes himself a temporary lunatic or idiot by his degrading vice, propagates his kind in procreation, and entails on his children the curse of the most hopeless fate."

Such being the influence of heredity on man's physical, mental, and moral being, what, it may be asked, are its bearings on public health? Briefly these—that each generation has enormous power over the well-being of those that follow; that acquired habits, whether for good or evil, may become more or less permanent in a race, the good being slowly developed and with difficulty retained, the evil readily implanted and with difficulty eradicated. It shows also that deterioration, however produced, as it affects families, may affect communities, in an ever-widening circle, until a whole race may become degenerate and disappear from amongst nations.

Section II.—Causes of Deterioration and Disease.

These may be divided into two classes—namely, social and material. As the material causes will be more or less fully discussed in succeeding chapters, the mere enumeration of the more important of them will suffice here, such as, impure air, impure water, insufficient or unwholesome food, dampness of soil, deficiency of warmth, etc. The removal of these causes is the principal aim of practical hygiene as enforced by legislative enactments. The social causes of deterioration and disease, on the other hand, are little, if at all,

controlled by State interference; and hence their removal, as far as possible, must depend mainly on individual or combined efforts dictated by a sense of duty, which may be either egoistic or philanthropic, as the case may be. It is here that the effects of education, whether imparted in the family circle and school, or from the pulpit and platform, or by the public press, will be tried and tested.

In a country such as this the social causes of deterioration and disease are multiform and intricate. Intemperance, immorality, injudicious marriages, excesses of every description, overwork, idleness, depressing passions, may be enumerated as the most disastrous. All of them tend to impair the constitution of the individual, or the well-being of the offspring, and in proportion to their prevalence they lower the standard of public health. Obviously, it is difficult to dissociate their separate effects in their influence on public health, because they seldom operate singly even in isolated cases. The intemperate man, for example, if not otherwise immoral, is too often housed in a home where the air is poisoned by overcrowding, and from which comfort and cleanliness are alike banished. And if it be urged that the unhealthy home is the result of the intemperance, it may also be affirmed that sometimes it is the cause, and that this, in the first place, may have been induced by an early or imprudent marriage. These, however, are speculations on which it is needless to enter, for the broad results, as affecting the well-being of society, are sufficiently distinct, and may be discussed more or less fully in detail.

1. *Intemperance.*—That the habitual use of alcoholic liquors, even though it be seldom carried to the verge

of intoxication, deteriorates the health, and is liable to result in actual disease, is a statement which few will be found to contradict. The main point at issue is rather, whether, for the great majority of healthy persons, habitual abstinence is not the best rule to be laid down. This question has been answered very strongly in the affirmative by Dr. Carpenter and other eminent authorities, not only on physiological grounds, but because extended experience has proved that whatever temporary augmentation of power may result from their occasional use, prolonged bodily or mental labour can be best sustained without them. The careful and exhaustive experiments recently conducted by Dr. Parkes and the late Count Wollowicz on two healthy men also tend to the same conclusion, and go very far to prove that not only is alcohol not a necessity, but that its use, even in small quantities, is not desirable in most cases. No doubt, when the diet is insufficient, or the digestion feeble, the moderate use of stimulants is decidedly beneficial; but as this applies to alcohol more as a therapeutic, than as a dietetic, agent, it would be out of place here to enter further into this part of the subject.

With regard, however, to the habitual and excessive use of alcoholic liquors, amounting to intemperance, the gravity of the effects admits of no question. Digestion is interfered with, the physical strength is undermined, and the nervous system becomes seriously impaired. The result of this nervous exhaustion is manifested by the tremulousness of the hands, the twitchings of muscles, and, above all, by the enfeebled will, which, in many cases, becomes powerless to resist the craving for drink which is ultimately induced. Moreover, the

perversion of the nutritive processes leads to fatty degeneration of the heart and blood-vessels, of the kidneys, liver, and other parts; and side by side with this diseased condition of body there is gradual loss of self-control, with perversion of the moral sense, so that, in many instances, the habitual drunkard becomes eventually a veritable dipsomaniac, whose only chance of cure is restraint in an asylum.

But these effects, grave though they be, do not end with the individual, for the law of heredity brands the offspring as victims of a diseased organisation, manifesting itself especially in a vitiated nervous system. For example, the craving for drink may itself be inherited, or the thieving and cunning propensities developed in the parent to obtain stimulants at all hazards, may become so intensified in the offspring as to render him a born thief and vagabond. Or, again, the parent's loss of mental power and moral discrimination may become displayed in the child as hopeless idiocy, or some other form of insanity. Obviously, it is not easy to collect accurate statistics in support of these statements, but the following will suffice for illustration:—Out of 300 idiots in the State of Massachusetts, whose histories were carefully investigated by Dr. Stowe, as many as 145 were the offspring of intemperate parents. Further, speaking in general terms, M. Morel, than whom no higher authority can be quoted, says, "I constantly find the sad victims of the alcoholic intoxication of their parents in their favourite resorts,—the asylums for the insane, prisons, and houses of correction. I as constantly observe amongst them deviations from the normal type of humanity, manifesting themselves not only by arrests of development and

anomalies of constitution, but also by those vicious dispositions of the intellectual order which seem to be deeply rooted in the organisation of these unfortunates, and which are the unmistakable indices of their double fecundation in respect of both physical and moral evil."

Not to dwell longer on this topic, I would briefly state that my own experience amongst convicts has fully convinced me that four-fifths of the prison-population are directly or indirectly the victims of intemperance;—directly, as regards the occasional, and indirectly, to a large extent, as regards the habitual, criminals. In other words, the great majority of the former lapse into crime through acquired drunken habits, while the great majority of the latter are congenitally criminal on account of the intemperance of their progenitors.

As regards the effects of intemperance in this twofold aspect on the public health, it is impossible to arrive at any accurate conception; but that the general sick-rate and death-rate of the population are both very considerably increased by this cause alone, there can be no doubt. Indeed, the growth of resolute conviction, which is at present observable among the masses, with respect to the abuse of alcohol, is the best evidence alike of the universality of the evil, and its danger to the well-being of the community.

2. *Immorality.*—Although licentiousness is happily not so prevalent in this country as to be largely productive of deterioration and disease, it is instructive to note how it has in former times told upon the fate of nations. And history furnishes no warning more sad and terrible than that displayed by the downfall of

ancient Greece. How came it to pass that this highly-gifted race, which had attained to a standard of intellectual superiority as far exceeding ours of the present day as ours exceeds that of the African negro, decayed and disappeared? The answer, which is given in Mr. Galton's words, is not far to seek—"Social morality grew exceedingly lax; marriage became unfashionable, and was avoided; many of the more ambitious and accomplished women were avowed courtesans, and consequently infertile, and the mothers of the incoming population were of a heterogeneous class. In a small sea-bordered country, where emigration and immigration are constantly going on, and where the manners are as dissolute as were those of Greece in the period of which I speak, the purity of a race would necessarily fail." (*Hereditary Genius.*)

3. *Injudicious or Unsuitable Marriages.*—This cause of deterioration refers to the marriage of persons who, from their condition in life, are unfit to rear a family, or who, from age, constitution, or consanguinity, are liable to procreate a diseased offspring. It will be at once seen that this subject touches the very foundation of a nation's prosperity and growth. For, in the first place, unthriftiness in marriage amongst all classes may lead in the long run to an increase of population which will exceed the means of healthy subsistence, just as it leads to poverty and disease in any case when a man can barely earn what is sufficient for his own wants. To quote Dr. Acland—"The reality of our difficulty about population is told in a few words—England and Wales are increasing by about 200,000 annually. This number will, of course, increase by a small increment. Since A.D. 1810, the population, which was 10,000,000,

has become 22,000,000, and, at the same rate, will become by A.D. 1920 over 45,000,000. The acres in England and Wales are about 37,325,000, including waste ground. There are now, therefore, nearly two acres per man; there will be in fifty years not one; in Glasgow, there are already 94 inhabitants to an acre; and in Liverpool, 103."—(*Lecture on National Health.*) Already, then, it may be said, the effects of over-population are threatening the well-being of the nation; and though it be true that emigration affords an outlet for numbers, the question arises whether the country is not drained of the useful and vigorous, rather than of its less useful and deteriorated, inhabitants.

Then, again, this unthriftiness in marriage prevails most extensively amongst the ignorant and degenerate, or, at all events, amongst those of the lower orders who hover on the verge of pauperism. They look upon parish relief as a prescriptive right if they beget more children than they can rear; and, in many instances, when once they do become pauperised, the system of relief encourages family increase, because the more numerous the children, the greater is the sum obtained for the use of the family generally. For it by no means follows that the whole of the sum obtained for each child is expended on that child;—there is always the possibility, especially in country districts, of a surplus being realised, however small, to be expended exclusively for the use of the demoralised parents; and this surplus is too often spent in drink. There is no doubt also that the frightful mortality amongst the children of the lower working classes who do not receive parish relief is not altogether to be attributed to defective sanitary arrangements or to insufficient nourishment.

In many instances there is intentional neglect, amounting to culpable homicide, for the remedies prescribed for the sick child are not administered, while the medical comforts obtained from the dispensary or from charitable persons for its recovery are appropriated by the parents. The child, at the best, is allowed to die, or its death is hastened, because its existence is felt to be a troublesome burden. Truly, the old Spartan custom of exposing weak and ailing children to certain death is still put in practice, even in civilised nations, and to an extent which only those who have done dispensary work in our large cities can well conceive.

This is one phase of the consequences of unthriftiness or imprudence in marriage. But there is another, which perhaps operates as a cause of sickness and mortality with equal severity—the practice, namely, of prolonging the period of weaning the child until the mother becomes weak, and her constitution, in all probability, permanently impaired; and this preventive check, which is well known amongst all classes, tells on the child as well as the mother; so that, in her anxiety not to beget too many children, she unconsciously ruins the health of those she already has begotten.

No wonder, in the face of such evils as these, that Malthus and others should have proposed a series of checks to prevent the procreation of large families, and amongst these should have insisted strongly on the advisability of delaying the period of marriage. But, as Mr. Galton has shown, even this check, were it adopted, would operate to the detriment of a mixed community, inasmuch as it is advanced as a course for the prudent to follow, while the imprudent are left to

act as they please. "Its effect would be such as to cause the race of the prudent to fall, after a few centuries, into an almost incredible inferiority of numbers to that of the imprudent, and it is therefore calculated to bring utter ruin upon the breed of any country where the doctrine prevailed. . . . It may seem monstrous that the weak should be crowded out by the strong; but it is still more monstrous that the races best fitted to play their part on the stage of life should be crowded out by the incompetent, the ailing, and the desponding."—(*Hereditary Genius.*)

Turning, now, to the other part of the subject—namely, the effects of *unsuitable* marriages—it may be stated at the outset that too early or too late marriages are punished by sterility, or by the procreation of offspring afflicted with a lowered vitality. M. Quetelet's deductions on this point, from a large number of statistics (see *Physique Sociale*), are as follows:—

(1.) Too early marriages result in sterility, or in the birth of children whose chance of surviving to the average period of life is lessened.

(2.) Marriages which are not infertile are productive of the same number of children, independently of age, provided that the average age of the husband does not exceed 33 years, nor that of the wife, 26. After these ages the number of children diminishes.

(3.) The greatest fecundity attends the marriage of men under 33 years of age to women under 26.

(4.) Other things being equal, those marriages are most fertile in which the age of the husband at least equals that of the wife, or does not greatly exceed it.

To these deductions might be added those of Dr. Matthews Duncan and others, which go to prove that,

apart from fecundity, the health of the mother, and consequently of the offspring, has a less chance of being deteriorated by delaying the woman's age of marriage to 25 or 26 years.

But the most disastrous results connected with unsuitable marriages are those in which morbid tendencies are found to form part of the organic patrimony of one or both parents. If, for example, the parents both spring from consumptive families, the chances are that the whole of the offspring will become victims to the disease; or, again, even should one of the parents come of a healthy stock, the danger to the offspring is by no means removed, although it is lessened; many of the children may escape, but it is seldom that they all do so. The same remarks apply to scrofula, and indeed, more or less, to all diseases of a chronic or adynamic nature. It is chiefly, however, in relation to so-called mental affections that the mischief of unsuitable marriages becomes apparent, for, according to Dr. Burrows, the percentage of cases due to hereditary influence reaches 84.

As regards consanguine marriages, it has already been shown that, inasmuch as any latent morbid tendency is likely to be the same in both parents, the danger of such tendency becoming developed in the offspring is greatly increased. But, apart from the existence of any latent tendency, too close breeding amongst human beings, as amongst animals, invariably leads to deterioration, and ultimate extinction. Hence it is that ancient aristocracies, reduced to repeated intermarriage, have become first degenerated physically, and have become finally extinct, sometimes by drifting into imbecility or dementia, or, at all events, by becoming

infertile. The following statistics will, however, illustrate more fully the sad heritage to which the offspring of consanguine marriages are doomed:—Amongst the children proceeding from 121 marriages of this description, M. Devay found that 22 were sterile, 27 deformed, and 2 were deaf mutes. Out of 34 marriages, investigated by Dr. Bemiss of Louisville, 7 were found to be infertile. From the 27 fertile marriages, 192 children were born; of these 58 perished in infancy or early life. Of the 134 who arrived at maturity, 46 appeared to be healthy, 32 deteriorated, 23 were scrofulous, 4 epileptic, 2 insane, 2 dumb, 2 blind, 4 imbecile, 2 deformed, 5 were albinos, 6 had defective vision, and 1 had chorea. The remainder were not reported on as regards physical condition. Dr. Howe's statistics, already referred to, are still more decided:—Out of 17 marriages between blood relations, resulting in the birth of 95 children, he found that 44 were idiots, 12 scrofulous, 1 deaf, 1 a dwarf, and only 37 who enjoyed tolerable health. M. Boudin, again, has calculated that whilst consanguine marriages in France only amount to 2 per cent of the whole number, the deaf and dumb children resulting from these marriages amount to nearly a quarter of the whole number. (See *A Physician's Problems*, by Dr. Elam.)

It would be easy to multiply these instances, but enough has been said to demonstrate how powerfully imprudent or unsuitable marriages must operate as a cause of deterioration and disease on the public health. All these points, however, must become generally known and fully realised before any amelioration can be expected; and though it be true that some writers look forward to the time when State interference may be

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exercised in this as in other directions, it is doubtful whether it would not give rise to evils greater than those which it would tend to repress.

Leaving out of consideration the mode of operation of other causes of deterioration, and merely glancing at the broad results when the material as well as social causes are taken into account, it becomes at once apparent that, whether the English race is or is not deteriorating as a whole, it is certainly exposed to this danger. Indeed, the constantly increasing preponderance of town population over rural population in numbers, and the fact that the average *physique* of the former is considerably below that of the latter, renders it highly probable that the standard is becoming imperceptibly lowered. At present, according to Dr. Beddoe's valuable statistics, the average stature of adult Englishmen of all classes is about 5 feet 6·6 inches (without shoes), but unfortunately there are no data by means of which any comparison can be made between this average and the average say, of fifty, or one hundred, years ago. Inferences can, therefore, only be drawn from the different statistics of the town and country populations of the present day, and these point conclusively to deterioration, even admitting the influence of original breeds. Thus, to take the returns from Cumberland and Westmoreland, exclusive of Carlisle, given in Dr. Beddoe's statistics, as representative of a country population, it appears that the average height is 5 feet 8·1 inches; whereas, in the neighbouring county of Lancashire, where the true native breeds used also to be undeniably tall, the average is as low, or lower, than that of England generally. But while the evidence of physical deterioration is manifest in the

town-bred population, it becomes still more pronounced in the degenerate classes of the community. Thus, I find that the average height of the 316 convicts received into Portsmouth prison during 1871 is 5 feet 5·0 inches; and Dr. Beddoe's statistics of the lunatics in London, Birmingham, and Nottingham, yield an average somewhat below this.

If, however, there is reason to fear that the average *physique* of the English race, in the rapid growth of town populations, has of late years become lowered, there are good grounds for believing that the deterioration has reached its culminating point. Already the results of sanitary improvements in many of our large towns are beginning to declare themselves, not only in a lessened sick-rate and death-rate, but in an apparently healthier tone of public opinion. The working classes in all parts of the country are bestirring themselves for more leisure and more pay, and so far they have succeeded. It remains to be seen whether the leisure will be spent in self-improvement, or the extra pay be judiciously applied, and not worse than wasted. Savings banks, Good-Templarism, the present diminution of pauperism and crime, are all of them hopeful signs; but it must not be forgotten that holidays and high wages may prove to be a curse instead of a blessing, if they are spent in lawless drinking bouts, and not according to the precepts of health and morality.

SECTION III.—PREVENTABLE DISEASE.

The remarks in the preceding section, fragmentary though they be, suffice to show that, apart from the mortality and sickness arising from material causes, such as impure air, impure water, or insufficient food,

there is a vast amount of preventable disease attributable to social causes, which legislative measures, or ordinary sanitary precautions, do not reach. So far as these causes are concerned, the hopes of progress and improvement, as already stated, must rest on education wide-spread and general. The fundamental principles of personal and domestic hygiene must become matters of intelligent conviction amongst all classes, and especially amongst the upper and middle, that they may help those of the lower who are unable to help themselves. For it cannot be denied that there are multitudes in all our large towns so heavily burdened with the load of a vitiated heritage, and so hemmed in with the barriers of foul air, filth, and want, that teaching and preaching can only be felt as bitter mockeries unless these barriers are first removed. Herein lie the duties of sanitary authorities, and in their compulsion by legislative means there is at last some hope that amelioration and enlightenment may penetrate even to these depths.

But limiting the estimate of preventable disease to the operation of causes removable by ordinary sanitary administration, the waste of life is still as needless as it is appalling. This, however, is a tale of culpable neglect, which requires no comment, and is best told in the words of the medical officer of the Local Government Board:—"It seems certain," writes Mr. Simon in 1871, "that the deaths which occur in this country are fully a third more numerous than they would be if our existing knowledge of the chief causes of disease were reasonably well applied throughout the country; that of deaths, which in this sense may be called preventable, the average yearly number in England and

Wales is about 120,000; and that of the 120,000 cases of preventable suffering which thus in every year attain their final place in the death-register, each unit represents a larger or smaller group of other cases in which preventable disease, not ending in death, though often of far-reaching ill effects on life, has been suffered. And while these vast quantities of needless animal suffering, if regarded merely as such, would be matter for indignant human protest, it further has to be remembered, as of legislative concern, that the physical strength of a people is an essential and main factor of national prosperity; that disease, so far as it affects the workers of the population, is in direct antagonism to industry; and that disease which affects the growing and reproductive parts of a population must also in part be regarded as tending to deterioration of the race.

"Then there is the fact that this terrible continuing tax on human life and welfare falls with immense over-proportion upon the most helpless classes of the community; upon the poor, the ignorant, the subordinate, the immature; upon classes which, in great part through want of knowledge, and in great part because of their dependent position, cannot effectually remonstrate for themselves against the miseries thus brought upon them, and have in this circumstance the strongest of all claims on a legislature which can justly measure, and can abate, their sufferings.

"There are also some indirect relations of the subject which seem to me scarcely less important than the direct. For where that grievous excess of physical suffering is bred, large parts of the same soil yield, side by side with it, equal evils of another kind, so that, in

some of the largest regions of insanitary influence, civilisation and morals suffer almost equally with health. At the present time, when popular education (which indeed in itself would be some security for better physical conditions of human life) has its importance fully recognised by the legislature, it may be opportune to remember that, throughout the large area to which these observations apply, education is little likely to penetrate, unless with amended sanitary law, nor human life to be morally raised while physically it is so degraded and squandered." (See *Thirteenth Report of the Medical Officer of the Privy Council.*)

At last the legislature has conferred the power of removing these evils on sanitary authorities throughout the country. The trust is one of life or death to thousands,—it remains to be seen how faithfully it will be fulfilled.

CHAPTER II.—FOOD.

SECTION I.—FUNCTIONS AND CONSTITUENTS OF FOOD.

WITHOUT entering into a discussion of the various chemico-physical changes which food undergoes in the living body, it may be broadly asserted that its ultimate destiny is the development of heat and other modes of motion, which together constitute the physiological phenomena of animal life. The potential energy with which the food is stored becomes converted into actual or dynamic energy, and is manifested in the body as heat, constructive power, nervo-muscular action, mechanical motion, and the like. But as food also supplies the materials which are requisite for the development and maintenance of the living fabric, as well as for the display of its various kinds of active energy, it may be inferred that inorganic and organic substances are both necessary. The organic alone are oxidisable, or capable of generating force, while the inorganic, though not oxidisable, are essential to the metamorphosis of organic matter which takes place in the animal economy.

The organic constituents of food are generally divided into nitrogenous, fatty, and saccharine compounds; and the inorganic, into water and saline matters. Both classes of constituents are present in all ordinary articles

of diet, whether they be derived from the animal or vegetable kingdom.

1. *Functions of the Nitrogenous Constituents.*—The nitrogenous constituents consist of albumen in its various forms, fibrine, syntonin or muscle-fibrine, casein, gluten, legumin, and other allied substances, such as gelatine. Their chemical composition is remarkably uniform, and, as they seem all capable of being reduced by the digestive process to a like condition, they can replace each other in nutrition, though not to an equal extent.

Up to a comparatively recent period, it was believed that nitrogenous constituents must first be converted into tissue before their dynamical energy can be elicited; in other words, that muscular force is entirely dependent on the metamorphosis of muscular tissue, and that urea, being the product of the change, ought to be regarded as a measure of the force. This was the doctrine taught by Professor Liebig, and it was generally accepted by physiologists until Drs. Fick and Wislicenus of Zurich published their famous experiments connected with their ascent of the Faulhorn. While these experiments proved that a non-nitrogenous diet will sustain the body during severe exercise for a short period, and without any notable increase in the amount of urea, the more carefully-conducted experiments subsequently made by Dr. Parkes showed that *possibly* the amount of urea is even lessened. If this view were confirmed, Dr. Parkes' inference would be rendered highly probable—the inference, namely, that muscle, instead of oxidising during labour, and becoming wasted by losing nitrogen, does in reality appropriate nitrogen, and grows, and that its exhaustion does not depend so

much on decay for the time being, as on an accumulation of the oxidised products of other food-constituents within its tissues. He takes care to point out, however, that in the long run some decay of muscle does take place, and that the amount of nitrogen must be increased as the work increases.

Judging from these and other experiments, it would therefore appear that, although the main functions of the nitrogenous constituents of food are the construction and repair of the tissues, they exercise other important functions of a regulative and dynamic nature not well defined. There is no doubt that a certain portion of them is directly decomposed in the blood, and so far they contribute to the maintenance of animal heat and the development of dynamic energy; but the experiments of Pettenkofer and Voit also tend to show that the nitrogenous substances composing the tissues determine the oxidation of the other constituents, or, in other words, that no manifestation of force is possible without their participation in the process.

2. *Functions of the Fatty Constituents.*—The fact that food containing a large proportion of fatty ingredients is invariably used by the inhabitants of cold countries, indicates that these constituents play an important part in the maintenance of animal heat. Indeed, it has been proved by experiment that the respiratory or heat-producing powers of fat are twice and a half as great as those of the other hydrocarbons, as starch or sugar. Fat also takes an active share in the conversion of food into tissue, and aids the removal of effete products from the system. The experiments already alluded to likewise show that its oxidation in the blood generates to a great extent the force which

is rendered apparent in locomotion or manual labour. Further, its distribution in the tissues gives rotundity to the form, serves to retain animal heat by its non-conducting properties, and greatly facilitates the working of the various parts of the living machine by lessening friction and preventing jarring by its elasticity.

3. *Functions of the Saccharine Constituents or Hydrocarbons.*—These constituents comprise cellulose, starch, and sugar; and, like the fatty constituents, are directly subservient to the maintenance of animal heat and the production of animal force. Starch is for the most part converted into dextrine, and by a further oxidation generates carbonic acid, which is given off by the lungs. As already stated, the heat-producing powers of these constituents are much inferior to those of fat, but they are capable of being converted into fat in the system, and are largely concerned in carrying on the digestion of nitrogenous substances.

4. *Functions of Water and Saline Matters.*—The principal functions of water in the animal economy are—the solution and conveyance of food to different parts of the system, the removal of effete products, the lubrication of the tissues, the equalising of the body temperature by evaporation, and the regulation of the chemical changes which take place in the processes of nutrition and decay. Saline matters, on the other hand, are the chief media for the transference of the organic constituents throughout the body. They are largely concerned in the consolidation of the tissues, and are supposed to convert unabsorbable colloids into highly diffusive crystalloids.

The functions of what are called the accessories of food, such as beverages, stimulants, etc., are still matters of speculation.

That all these four classes of constituents should be present in a well-arranged dietetic scheme is alike taught by experience and proved by experiment. No single class is capable of sustaining life by itself, although it is certain that health can be maintained for some time on a diet consisting of the nitrogenous, fatty, and saline matters.

The separate amounts and relative proportions of the several classes of constituents required in a standard diet for a healthy male European adult, of average size and weight, and performing a moderate amount of work, are given in the following table:—

Amounts.		Relative Proportions.
Water-free Substances given daily.	Ounces avoir.	
Nitrogenous substances .	4·587	1
Fatty ,, .	2·964	·6 nearly.
Saccharine ,, .	14·257	3
Saline ,, .	1·058	·2
Total water-free food .	22·866	

Although no single standard will meet all cases, the above, which is given by Dr. Parkes, and quoted by him from Moleschott's numbers, is found to accord fairly with the observations of numerous other physiologists.

Section II.—Nutritive Values of Food.

As the phenomena of nutrition depend mainly on the chemical interchanges of nitrogen and carbon with oxygen, different articles of diet have been estimated according to the amount of nitrogen and carbon which they contain. But inasmuch as the actual value of

the carbonaceous compounds in fatty constituents is about two and a half times as great as that of the saccharine constituents, it is evident that, in framing a table of alimentary equivalents, the amount of carbon must be stated as having the same nutritive value throughout. In the following table, therefore, which is given by Dr. Letheby in his valuable work on *Food*, the amount of carbonaceous matters in the different articles of diet are estimated as starch:—

	GRS. PER POUND.			GRS. PER POUND.	
	Carbon.	Nitrogen.		Carbon.	Nitrogen.
Split peas .	2699	248	New milk . .	599	44
Indian meal .	3016	120	Skim cheese .	1947	483
Barley meal .	2563	68	Cheddar cheese .	3344	306
Rye meal . .	2693	86	Bullocks' liver .	934	204
Seconds flour .	2700	116	Mutton . .	1900	189
Oatmeal . .	2831	136	Beef . . .	1854	184
Bakers' bread .	1975	88	Fat pork . .	4113	106
Pearl Barley .	2660	91	Dry bacon . .	5987	95
Rice . . .	2732	68	Green bacon .	5426	76
Potatoes . .	769	22	White fish .	871	195
Turnips . .	263	13	Red herrings .	1435	217
Green vegetables	420	14	Dripping . .	5456	—
Carrots . .	508	14	Suet . . .	4710	—
Parsnips . .	554	12	Lard . . .	4819	—
Sugar . .	2955	—	Salt butter .	4585	—
Treacle . .	2395	—	Fresh butter .	6456	—
Buttermilk .	387	44	Cocoa . .	3934	140
Whey . .	154	13	Beer and porter .	274	1
Skimmed milk .	438	43			

As this table contains almost all the articles which are likely to be met with in a common dietary, it becomes no difficult matter to calculate the total amount of carbon and nitrogen which any such dietary yields, and to compare the results with other dietaries that have been calculated in the same way. It is neces-

sary to add that the nutritive equivalents apply to articles in their uncooked state, and that the meat is boned.

Section III.—Food and Work.

It has already been stated that, in addition to maintaining the body in a healthy state, the potential energy of food is the sole source of the active energy displayed in mechanical motion or work. It therefore follows that the diet must be increased as the work increases; and the question arises at the outset,—What is the minimum amount of food on which a man of average size and weight can subsist without detriment to health? From a large number of observations made by Dr. Lyon Playfair and others on the dietaries of prisons and workhouses, and by Dr. Edward Smith on the amounts of food consumed by the Lancashire operatives during the cotton-famine, it would appear, according to Dr. Letheby, that a barely sustaining diet should contain about 3888 grains of carbon, and 181 grains of nitrogen. In round numbers, and taking a somewhat liberal view of the question, Dr. Edward Smith has proposed the following averages as representing the daily diet of an adult man and woman during periods of idleness:—

	Carbon (grains).	Nitrogen (grains).
Adult man . . .	4300	200
Adult woman . . .	3900	180
Average adult .	4100	190

Taking the mean of all the researches which have been made by eminent physiologists, Dr. Letheby gives the following as the amounts required daily by an

adult man for idleness, for ordinary labour, and for active labour :—

Daily diets for	Nitrogenous. Ozs.	Carbonaceous. Ozs.		* Carbon. Grs.	Nitrogen. Grs.
Idleness .	2·67	19·61	=	3816	180
Ordinary labour	4·56	29·24	=	5688	307
Active labour	5·81	34·97	=	6823	391

And here it may be observed that the general correctness of these averages is fully borne out by the results of the numerous experiments which have been made to ascertain the amount of carbon and nitrogen actually excreted by adult men under different conditions of diet and exercise. These results have also been summarised by Dr. Letheby, and the averages are found to correspond very closely with those just given, thus :—

Daily requirements of the Body (LETHEBY).

		Nitrogenous Food. Ozs.	Carbonaceous Food. Ozs.		Carbon. Grs.	Nitrogen. Grs.
During idleness as determined	By dietaries	2·67	19·61	=	3816	180
	By excretions	2·78	21·60	=	4199	187
	Average	2·73	20·60	=	4005	184
Routine work as determined .	By dietaries	4·56	29·24	=	5688	307
	By excretions	4·39	23·63	=	4694	296
		4·48	26·44	=	5191	302

The actual amounts of carbonaceous and nitrogenous matters which are consumed by low-fed and well-fed operatives are given in the following tables :—

Weekly Dietaries of Low-fed Operatives, calculated as Adults (Dr. E. Smith).

Class of Labourer.	Bread stuffs.	Potatoes.	Sugars.	Fats.	Meat.	Milk.	Cheese.	Tea.	Containing Carbon.	Nitrogen.
	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Grs.	Grs.
Needle-women (London)	124·0	40·0	7·3	4·5	16·3	7·0	0·5	1·3	22,900	950
Silk-weavers (Coventry)	166·5	33·7	8·5	3·6	5·3	11·6	1·0	0·3	27,028	1104
Silk-weavers (London)	158·4	43·8	8·8	5·5	11·9	4·3	0·3	0·6	48,288	1165
Silk-weavers (Macclesfield)	138·8	26·6	6·3	3·4	3·2	41·9	0·9	0·3	27,346	1177
Kid-glovers (Yeovil)	140·0	84·0	4·3	7·1	18·3	18·3	10·0	0·9	28,623	1213
Cotton-spinners (Lancashire)	161·8	22·6	14·0	3·1	5·0	11·8	0·7	0·7	29,214	1295
Hose-weavers (Derbyshire)	190·4	64·0	11·0	3·9	11·9	25·0	2·2	0·4	33,537	1316
Shoemakers (Coventry)	179·8	56·0	10·0	5·8	15·8	18·0	3·3	0·8	31,700	1332
Farm labourer (England)	196·0	96·0	7·4	5·5	16·0	32·0	5·5	0·5	40,673	1594
Farm labourer (Wales)	224·0	138·7	7·5	5·9	10·0	85·0	9·8	0·5	48,354	2031
Farm labourer (Scotland)	204·0	204·0	5·8	4·0	10·3	124·8	2·5	0·7	48,980	2348
Farm labourer (Ireland)	326·4	92·0	4·8	1·3	4·5	135·0	—	0·3	43,366	2434
Mean of all	184·2	78·1	8·0	4·5	10·7	42·9	3·1	0·6	34,167	1500
Average per day	26·3	11·1	1·1	0·6	1·5	6·1	0·4	0·1	4,881	214

Daily Dietaries of Well-fed Operatives (PLAYFAIR).

Class of Labourer.	Flesh-former.	Fats.	Starch and Sugar.	Containing		Containing	
				Carbon-aceous.	Nitro-genous.	Carbon.	Nitro-gen.
	Ozs.	Ozs.	Ozs.	Ozs.	Ozs.	Grs.	Grs.
Fully-fed tailors	4·61	1·37	18·47	21·64	4·61	5136	325
Soldiers in peace	4·22	1·85	18·69	22·06	4·22	5246	297
Royal Engineers (work) . . .	5·08	2·91	22·22	29·38	5·08	6494	358
Soldiers in war .	5·41	2·41	17·92	23·48	5·41	5561	381
English sailor .	5·00	2·57	14·39	20·40	5·00	4834	252
French sailor .	5·74	1·32	23·60	26·70	5·74	6379	405
Hard-worked weavers . .	5·33	1·53	21·89	25·42	5·33	6020	375
English navvy (Crimea) . .	5·73	3·27	13·21	21·06	5·73	5014	404
English navvy (Railway) . .	6·84	3·82	27·81	37·08	6·84	8295	482
Blacksmith . .	6·20	2·50	23·50	29·50	6·20	6864	437
Prize-fighters (training) . .	9·80	3·10	3·27	10·70	9·80	4366	690
Mean of all .	5·81	2·42	18·63	24·31	5·81	5837	400
Mean of low-fed operatives .	3·04	0.64	21·18	22·78	3·04	4881	214

As an addendum to these data, and by way of contrast, I may here give some particulars with reference to the dietaries of the convicts confined in English prisons. In the hard-labour prisons, where the great majority of the prisoners are employed at active out-door work, there are two scales of diet—viz., the light-labour diet and the full-labour diet. I have carefully calculated the nutritive values of the various articles of food contained in these diets, according to the equivalents given in a preceding table, and the results are as follows :—

	DAILY AVERAGE.	
	Carbon. Grs.	Nitrogen. Grs.
Light-labour diet	4651	224
Full-labour diet . . .	5289	255

What is called light labour applies to manual work requiring very little muscular exertion, while full labour embraces a variety of occupations, such as tailoring, shoemaking, artizan work, and navvy work. From the averages already given, it will be inferred that the light-labour diet is quite sufficient for the easy nature of the work, and, practically, with few exceptions, this is found to be the case. The prisoners employed at light labour are all more or less invalid or crippled, and although almost all of them could take more food, they are not found to lose weight, except in isolated cases. With regard to the practical working of the full-labour diet, however, this much cannot be said; for while prisoners employed at comparatively easy labour, such as artizan work, do not lose weight to any extent, those employed at the more arduous kinds of labour, such as navvy work, almost invariably lose a great deal, and after a time must be removed to lighter work to recruit. In whole gangs of prisoners employed at filling and wheeling barrows of clay, for example, I have found an average loss of weight of over 13 lbs. per prisoner, the loss accruing within a period of about two months after they had been put to such work. The consequence is, that in a hard-labour prison the convicts must be continuously shifted from hard to lighter work, and, after recruiting, from lighter to hard, otherwise they would completely break down, on account of the insufficiency of the full-labour diet for the severer kinds of prison labour. In military prisons, according to Dr. Letheby, where the dietary contains as much as 5090 grains of carbon and 256 grains of nitrogen daily, even for short periods of confinement, many of the prisoners lose weight, and give evidence of other signs of decay, so

that it is found necessary to increase the diet for longer periods to 6362 grains of carbon and 317 of nitrogen. Of course, military prisoners require more food than convicts, independently of the nature of the work at which they may be employed, inasmuch as they are larger men, and the ordinary physiological wants of the body demand a proportionately greater amount of nutriment. But the difference in stature between the two classes of prisoners does not account for such a difference in diets, and I have no doubt that convicts employed at active out-door labour would require at least as much as is represented by the average diet for ordinary labour given by Dr. Letheby—viz., a diet containing 5688 grains of carbon and 307 grains of nitrogen daily, to maintain them in good health, and prevent serious loss of weight.

Section IV.—Construction of Dietaries.

By reference to the numerous data already given, it will not only be easy to calculate the nutritive value of any given dietary, but a reliable opinion may be formed as to its suitability as well as sufficiency under specified circumstances. It now remains to point out the more important principles which ought always to be kept in view in the construction of dietaries; and, apart from the influence of work, which has already been considered, they may be briefly summarised as follows:—

1. *Influence of Sex.*—In the case of in-door operatives, the dietaries of women should be about one-tenth less than those of men.

2. *Influence of Age.*—Up to nine years of age, a child should be dieted chiefly on milk and farinaceous

substances. At ten years of age it will require half as much nutriment as a woman; and at fourteen quite as much as a woman. Young men who have not reached their full growth, but who are doing the same amount of work as adult men, require more food than the latter.

3. *Selection of Food.*—This embraces a variety of considerations, such as—

(1.) *The relative proportions of proximate constituents.*—These have already been shown in Moleschott's numbers quoted by Dr. Parkes, and they correspond very closely with those given by Dr. Letheby, viz. 22 of nitrogenous substances, 9 of fat, and 69 of starch and sugar. Whether the diet be mixed or purely vegetable, the same proportions hold good, and the results of experience prove that they are substantially correct. For example, articles of food which are deficient in one class of constituents, are invariably associated with others which contain an excess of them. Thus we have butter, or milk, or cheese, with bread; bacon, with veal, liver, and fowl; melted butter or oil, with fish; and so on. Such combinations are also of great service in aiding the digestibility of food. For reasons to be afterwards stated, every dietary should contain fresh vegetables.

(2.) *Variety of Food.*—But even when the proper proportions of constituents are provided for in a dietary, it is further necessary that certain articles belonging to the same class be varied from day to day, otherwise the appetite cloys. Beef should alternate with mutton, for example; or variety may be secured by different modes of cooking the same article. Indeed, it is not too much to say, that the art of cookery is a matter of national importance, not only because it renders food palatable,

but because the more it is studied and practised, the greater is the economy which may be effected. It is chiefly in this respect that beverages, condiments, etc., become such valuable dietetic adjuncts.

(3.) *Digestibility.*—This also in great measure depends upon the mode of cooking.

(4.) *Price.*—For much practical information on this and other points, see Dr. Edward Smith's *Practical Dietary,* or his Report on the Food of the Lancashire Operatives, in the Fifth Report of the Medical Officer to the Privy Council.

4. *Number and distribution of Meals.*—Experience teaches that three meals daily are best suited to the wants of the body. Dr. Edward Smith, in his physiological diet of 4300 grains of carbon and 200 of nitrogen, distributes the amounts as follows:—

	Carbon. grs.	Nitrogen. grs.		Carbonaceous. oz.	Nitrogenous. oz.
For Breakfast . .	1500	70	=	6·62	1·04
For Dinner . . .	1800	90	=	7·85	1·34
For Supper . . .	1000	40	=	4·52	0·59
Total daily . .	4300	200		18·99	2·97

5. *Climate.*—Other things being equal, carbonaceous substances ought to contain a preponderance of fatty constituents in cold climates, and of starchy or farinaceous, in warm climates. This also applies to seasonal variations.

Section V.—Preserved Foods.

Only a few of these need be mentioned.

1. *Liebig's Extract.*—This is more especially valuable to the traveller or the invalid. According to Dr.

Parkes, it is very restorative, removing all sense of fatigue after great exertion. Its nutritive qualities are inferior to those of ordinary beef-tea, but it can often be taken by an invalid when beef-tea would be rejected; and it has the further advantage of being readily prepared.

2. *Preserved Meat.*—What is known as Australian meat has the most extensive sale. Weight for weight, it is not so nutritious as properly cooked fresh meat, because the process of preservation requires that it should be over-cooked. The great difference in price, however, more than compensates for this slight disadvantage, and on the score of economy alone it deserves to be extensively used. Large quantities of it are now consumed in workhouses and asylums. It is best used cold, or warmed and mixed with potatoes and vegetables to form a stew; or it may be minced and warmed. In Dr. Williams' experiments in the Sussex County Asylum, the patients were allowed amounts equal to the uncooked fresh meat daily ration, with the result of a slight gain in weight in 13 of the 20 experimented on at the end of a month, the weight of the others remaining stationary.

3. *Preserved Vegetables.*—When fresh vegetables cannot be procured in sufficient quantity, dried vegetables should be employed to make up the deficiency. In lieu of potatoes in the early part of summer, preserved potatoes may be used, but as they are apt to pall on the appetite, other substitutes, such as a mess of rice and cabbage, or pease-pudding, should be given on alternate days.

4. *Preserved Milk.*—According to recent analyses conducted by Mr. Wanklyn, the condensed milk pre-

pared by the Anglo-Swiss, Newnham's, and the English Condensed Milk, Companies, consists of pure milk sweetened with a little sugar. As one volume of the condensed milk contains the nutritive material of four volumes of fresh milk, it should be diluted with three times its volume of water when used.

Section VI.—Examination of Food.

It need scarcely be said at the outset that a thorough practical knowledge of the qualities and appearances presented by the various articles of diet, in their wholesome or unadulterated state, is a necessary qualification for the detection of unwholesome or adulterated specimens.

1. *Meat.*—The characters of good meat may be enumerated as follows :—

(1.) On section, it should present a marbled appearance from intermixture of streaks of fat with muscle. This shows that the animal has been well fed.

(2.) The colour of the muscle should neither be too pale nor too dark. If pale and moist, it indicates that the animal was young or diseased; and if dark or livid, it shows that in all probability the animal was not slaughtered, but died with the blood in it.

(3.) The fat should be firm to the touch, not moist or sodden, and should be free from hæmorrhagic points.

(4.) Any juice exuding from the meat should be small in quantity, be of a reddish tint, and give a distinctly acid reaction to test-paper. Good meat should dry on the surface after standing a day or two. The juice of bad meat is alkaline or neutral.

(5.) The muscular fasciculi should not be large and coarse, nor should there be any mucilaginous or puru-

lent-looking fluid to be detected in the intermuscular cellular tissue.

(6.) The odour should be slight, and not by any means disagreeable. An unpleasant odour indicates commencing putrefactive change, or that the meat is diseased. By chopping a portion of the meat into small pieces, and afterwards drenching it with warm water, any unpleasantness of odour will be more readily detected. Another good plan is to thrust a long clean knife into the flesh, and smell it after withdrawal.

If the meat is at all suspicious, the muscular fibre should be examined under the microscope. The smaller *cysticerci* and *trichinæ* can only be detected in this way. The brain and liver should also be examined for hydatids, the lungs for multiple abscesses, and the ribs for pleuritic adhesions. To detect cattle-plague, the mouth, stomach, and intestines should be examined.

According to Dr. Letheby, it is the practice in the City of London to condemn the flesh of all animals infected with parasitic disease, such as measles, flukes, etc.; of animals that may have been suffering from acute, febrile, or wasting diseases; and of those which have died from natural causes or by accident; as well as all meat tainted with physic, or in a high state of putrefaction. Bad-smelling sausages should always be condemned.

In apportionating rations, 20 per cent must be allowed for bone. The loss in weight by cooking varies from 20 to 30 per cent.

2. *Flour.*—What is called good household flour or "seconds" should contain very little bran, be quite white, or only slightly tinged with yellow, and should give no acidity or musty flavour to the taste. It should

not be lumpy or gritty to the touch, nor should it yield any odour of mouldiness to the sense of smell. When made into a paste with a little water, the dough should be coherent and stringy.

The amount of gluten can be ascertained by washing carefully a known quantity of flour, made first into a rather stiff dough, until the water comes off quite clear. The gluten, when baked or dried, should be clean-looking, and should weigh at least 8 per cent of the quantity of flour taken for examination. A good flour will yield 10 to 12 per cent. Bad flour gives a dirty-looking gluten, which is deficient in cohesion, and cannot be drawn out into long threads.

Flour is sometimes adulterated with barley-meal, maize, rice, potato-starch, etc. Samples of doubtful quality should therefore be examined microscopically. *Fungi, vibriones,* and the *Acarus farinæ,* are detected in flour which is undergoing putrefactive change.

3. *Bread.*—The crust should be well baked, not burnt. The crumb should not be flaky or sodden, but regularly permeated with small cavities. The taste and smell should both be agreeable, and free from acidity. Unless there is a considerable quantity of bran in the flour, the colour should be white, not dark or dirty-looking.

Good flour, well baked, yields about 136 lbs. of bread per 100 lbs. of flour, and adulteration is chiefly directed to increase this ratio by making the gluten hard, and the bread more retentive of water. This the dishonest tradesman effects by adding alum, copper sulphate, or a gummy mixture of ground rice. The bread may be recognised by its becoming sodden and doughy at the base after standing for some time.

4. *Oatmeal.*—Good oatmeal is generally roughly ground, and contains a fair proportion of envelope freed from the husks. If husks are present, the probability is that the meal has been adulterated with barley. The starch should not be discoloured, and the meal itself should be agreeable to the palate. If the meal looks suspicious, it should be examined microscopically.

5. *Milk.*—Pure cow's milk, when placed in a tall narrow glass vessel, should be perfectly opaque, of a full white colour, free from deposit, and should yield from 6 to 12 per cent of cream by volume. As it is frequently adulterated with water, the specific gravity is a most important test of the quality, and hence the value of the lactometer. The specific gravity varies from 1028 to 1032; if it falls below 1026 it shows that the milk is either very poor or that a certain amount of water has been added. The following table by Dr. Letheby indicates approximatively the amount of water-adulteration according to the specific gravity and percentage of cream:—

	Specific Gravity.	Percentage volume of cream.	Specific Gravity when skimmed.
Genuine milk	1030	12·0	1032
Do. with 10 per cent water	1027	10·5	1029
Do. ,, 20 ,, ,,	1024	8·5	1026
Do. ,, 30 ,, ,,	1021	6·0	1023
Do. ,, 40 ,, ,,	1018	5·0	1019
Do. ,, 50 ,, ,,	1015	4·5	1016

When milk is largely adulterated with water, other substances, such as treacle, salt, and turmeric, are sometimes added to improve the flavour and appearance; but, generally speaking, the use of a graduated glass vessel to determine the percentage of cream, and test-

ing by the lactometer, will enable one to give a reliable opinion as to whether the milk is genuine or not.

6. *Butter.*—Butter should give no unpleasant or rancid taste. Adulteration with water or animal fats is best detected by melting the butter in a test-tube; the water, salt, or other substances remaining at the bottom. After separation of the casein by melting, good butter is entirely soluble in ether at 65° Fahr., while the fat of beef or mutton dissolves with great difficulty, and leaves a deposit. Adulteration with potato or other starch can be at once detected by iodine. Good butter, when melted, should yield a clear-looking oil, with little deposit of water or other substance.

7. *Cheese.*—The quality of cheese is determined by the taste and consistence. Inferior cheeses are often soft and leathery, owing to the amount of water which they contain. Starch, which is sometimes added to increase the weight, may be detected by iodine.

8. *Eggs.*—An average-sized egg weighs about 2 oz. avoir. Fresh eggs, when looked through, are more transparent at the centre; stale ones, at the top. In a solution of 1 of salt to 10 of water, good eggs sink, while the stale ones float.

9. *Potatoes* should be of good size, give no evidence of disease, be firm to the touch, and, when cooked, should not be close or watery.

10. *Tea.*—According to Dr. Letheby, the *bloom* or *glaze* of black and green tea is generally artificial. In the case of black tea, it sometimes consists of a coating of black-lead; and in that of green tea, it is usually a mixture of Prussian blue, turmeric, and China clay. Both kinds of adulteration are detected by shaking the leaves in cold water, straining through muslin, and

afterwards examining the deposit. Inferior mixtures, such as Maloo mixture, Moning congou, Pekoe siftings, etc., are largely imported into this country, and consist of exhausted tea-leaves, leaves of other plants, iron-filings, etc., with only a little good tea.

Good tea should yield a pleasant aroma, alike in the dry state and when infused in boiling water, and the flavour of the infusion should be agreeable. If the tea is suspicious, the infused leaves should be spread out and carefully scrutinised, and any powdery deposit examined under the microscope.

11. *Coffee.*—The principal adulteration of coffee is chicory. The adulteration may be detected either by microscopic examination or by sprinkling a portion of the suspected sample on the surface of water, when the coffee will float and the chicory sink. The presence of chicory is also indicated if, on opening a package of coffee, the contents are found to be caked, or show any signs of caking.

Section VII.—The Effects of Insufficient or Unwholesome Food on Public Health.

1. The minor effects of insufficient food are generally so intimately associated with those of other causes of disease, that it is impossible to estimate, with any approach to accuracy their separate influence on public health. For, as Mr. Simon eloquently observes, "Long before insufficiency of diet becomes a matter of hygienic concern,—long before the physiologist would think of counting the grains of nitrogen and carbon which intervene between death and starvation,—the household will have been utterly destitute of material comfort; clothing and fuel will have been even scantier

than food; against inclemencies of weather there will have been no adequate protection; dwelling-space will have been stinted to the degree in which overcrowding produces or increases disease; of household utensils and furniture there will have been scarcely any,—even cleanliness will have been costly or difficult; and if there still be respectful endeavours to maintain it, every such endeavour will represent additional pangs of hunger. The home, too, will be where shelter can be cheapest bought,—in quarters where there is commonly least fruit of sanitary supervision, least drainage, least scavenging, least suppression of public nuisances, least, or worst, water-supply, and, if in town, least light and air. Such are the sanitary dangers to which poverty is almost certainly exposed, when it is poverty enough to imply scantiness of food." And this picture, dark though it may appear, represents the condition of thousands who are struggling hard for very existence, and yet are all the while unsolicitous of relief. But when to these are added the numbers that swell the pauper list, and crowd the workhouses, with the famishing and permanently disabled, some conception may be formed of the wide-spread suffering and disease which follow in the wake of actual want.

The symptoms of failing health produced by insufficient diet, as observed in individual cases, are somewhat as follows:—There is gradual loss of flesh, advancing to extreme emaciation. The pulse becomes feeble, and the complexion sallow. Exertion brings on attacks of palpitation, vertigo, and transient blindness, until at last the patient falls a victim to some form of adynamic disease. Of this train of symptoms no more notable example could be quoted than the account

given of the sanitary condition of Millbank Prison in 1823. The prisoners confined in this establishment had previously received a daily diet of 31 to 33 oz. of dry nutriment, when it was resolved to reduce this allowance to 21 oz., and to exclude from the diet animal flesh, or nearly so. Hitherto, the prison had been considered healthy, but within a few months after the new diet-scale had been introduced, the health of the inmates began to give way, the first symptoms being loss of colour, gradual loss of flesh, and general debility. At last, numbers were attacked with diarrhœa, dysentery, and scurvy, and cases of convulsions, maniacal delirium, and apoplexy became common. About 52 per cent of the prisoners were more or less affected in this way; and to prove that the reduction of the diet was the chief, if not sole cause of the epidemic, the prisoners employed in the kitchen, and who were allowed 8 oz. additional bread daily, continued in good health, while the alarming sick-rate amongst the others was not diminished until the diet was increased.—(*Carpenter.*)

Similar observations to these were made amongst the prisoners confined in Fort Sumter during the late American war. The diet of the 30,000 inmates consisted of only $1\frac{1}{4}$ lb. meal and $\frac{1}{3}$ lb. bacon daily per head, and sometimes this allowance was reduced. As a consequence of this and other deplorable hygienic defects connected with the prison, 10,000 Federals died within a period of less than seven months, the prevailing diseases being diarrhœa, dysentery, scurvy, and hospital gangrene.—(*Carpenter.*)

Again, the terrible mortality which prevailed amongst the British troops in the Crimean war was clearly attri-

butable to the insufficiency of the food-supply. No extra allowance was granted for the increased exertion and the exposure to cold; and the result was, that within a few months the deaths from diarrhœa, dysentery, scurvy, and fever, rose to 39 per cent, and in some cases to 73.—(*Letheby.*)

As regards the civil population, the history of relapsing fever is almost exclusively a history of the ravages of disease arising from destitution; and the famines of the present century, especially those of 1817 and 1847, need only be referred to as evidence on this point. Further, the connection of scurvy with an insufficient or badly-arranged dietary is now so clearly established that it has been laid down as an axiom—the privation of vegetable food is its one essential cause, and the giving of it is its one essential counteraction.

2. *Unwholesome Food.*—There is so much uncertainty with regard to the effects of eating what is called *unsound meat,* that Dr. Letheby observes, "I feel that the question of the fitness of such meat for food is in such an unsettled state, that my action in the matter is often very uncertain; and I should like to have the question experimentally determined; for, as it now stands, we are either condemning large quantities of meat which may be eaten with safety, and are therefore confiscating property, and lessening the supply of food; or we are permitting unwholesome meat to pass almost unchallenged in the public markets." No doubt, much of the apparent immunity from disease enjoyed by the large numbers who unwittingly indulge in unwholesome food at times, is to be attributed to the antiseptic power of good cooking, but there are also many instances on record in which food of the most putrid description

is devoured without producing any ill effects. Thus, according to Sir Robert Christison, there are whole tribes of savages who eat with impunity rancid oil, putrid blubber, and stinking offal; and in this country game is not considered to be in a fit state for the epicure's table until it is undergoing rapid putrefactive change. Admitting all this, however, there is abundant evidence to prove that serious consequences resulting from the use of unsound meat are of frequent occurrence, and in all probability a large proportion of cases of obscure disease owe their origin to the same cause. Moreover, as Dr. Parkes truly observes, it is but only logical to conclude from general principles that, as all diseases must affect the composition of animal flesh, and as active putrefactive change must at all events deteriorate its nutritive value, it is of the utmost importance for health that these substances should be obtained in as sound a condition as possible.

The following is a brief abstract of the more important facts connected with this part of the subject:—

(1.) *Putrid Meat.*—On the whole, this may be said to be wasteful rather than positively injurious, but there are numerous cases recorded in which it has produced serious disease. Vomiting, diarrhœa, and low fever of a typhoidal type, are the chief symptoms. Putrid sausages are especially dangerous. According to an official return, it appears that in Wurtemberg alone, during the last fifty years, there have been 400 cases of poisoning from German sausages, and of these 140 were fatal.

(2.) *Diseased Meat.*—Here, again, the evidence is of the same conflicting character. According to Dr. Letheby, enormous quantities of the flesh of animals that died of rinderpest in 1863, and more recently of

pleuro-pneumonia, have been sent to the London market, sold, and eaten, without having produced any tangible ill effects. It is also well known that Scotch shepherds indulge largely in *braxy*, or diseased mutton, with apparent impunity; and, according to M. Decroix, the whole of the inhabitants of Paris would have suffered during the late siege if diseased meat were to any extent dangerous.

In the face of such evidence as this, it really becomes a question of public importance whether the flesh of *all* animals that have died diseased should be condemned. As a matter of fact, about one-fifth of the meat in the London market, according to Professor Gamgee, is of this description, and it is quite possible that, if it were sold under its true character, and proper precautions were taken with regard to selection and cooking, the ill effects which sometimes attend its use might not occur. Of course, such meat would be of inferior quality, but being so, it would be much cheaper, and within the reach of many who are sorely in want of animal flesh, but cannot buy it at its present price. As it is, however, the butcher sells it under a fictitious character, and it is therefore the duty of the health officer to condemn it.

In the numerous cases of illness which have been attributed to the use of diseased meat, the symptoms are very similar to those occasioned by the use of putrid meat. The exceptional symptoms apply chiefly to the development of parasitic disease. Thus, the *Cysticercus cellulosus* of the pig produces the *Tænia solium*, and that of the ox or cow the *Tænia medio-canellata*. The *trichina* disease, again, which has lately been so prevalent in many parts of Germany and elsewhere, is

due to the *Trichina spiralis* in pork; and the *ecchinoccus disease* owes its origin to the flesh of sheep and cattle which have become diseased by the tænia of the dog. It appears that all these parasites are destroyed if the meat is thoroughly cooked before being eaten.

3. As regards unwholesome vegetable food, it may be said that all food of this description which has become mouldy is dangerous. On the Continent, the ergot of rye has been productive of serious epidemics, and in this country alarming symptoms have frequently followed the use of flour which contains the ground seeds of *Lolium temulentum*, or darnel.

In connection with the subject of unsound food, some notice should also be taken of the occasional spread of specific disease through the agency of milk. Thus, Professor Bell of St. Andrews relates an outbreak of scarlet fever in that town, which shows very conclusively that the fever-poison was distributed by the milk-carrier, or, what is more probable, that the diseased cuticle from the woman and children, who vended the milk, actually passed into it, and that in this way the poison was introduced.—(*Lancet*, 1870.) Again, Dr. Taylor of Penrith gives an account of a somewhat similar outbreak, in the *British Medical Journal*, 1870, where he also relates a case in which he believes that the specific virus of enteric fever was introduced into several families by the agency of contaminated milk. Further, Dr. Ballard (*Lancet*, 1870) records an outbreak of enteric fever in Islington, which he attributed to the washing of the milk-cans with water derived from a tank which was found to communicate with two

old drains, and one of these with the pipe of a water-closet. Whether the milk was adulterated with the same water was not ascertained, but the evidence, both positive and negative, rendered it tolerably certain that the disease was propagated in this way.

CHAPTER III.

AIR: ITS IMPURITIES, AND THEIR EFFECTS ON PUBLIC HEALTH.

SECTION I.—COMPOSITION.

PURE AIR, according to the numerous analyses of Dr. Angus Smith, is composed of 20·99 per cent by volume of oxygen, ·033 per cent of carbonic acid, and the rest of nitrogen, watery vapour, and traces of ammonia. With the exception of carbonic acid and aqueous vapour, the relative proportions of the other constituents remain tolerably constant throughout the globe. In this country the amount of oxygen varies from 20·999 per cent in the sea air on the coast of Scotland, to 20·910 in Manchester during frost and fog, while the carbonic acid ranges from ·03 to ·05 per cent. The following averages of analyses, quoted from Dr. Smith's recent work on *Air and Rain*, represent the more important variations in the open air percentages of carbonic acid:—

	Carbonic Acid in 100 parts. Averages.
Different parts of Scotland, and at various altitudes	·0336
Perth city and outskirts	·04136
Closer parts of Glasgow	·0539
Opener parts of Glasgow	·0461
Suburbs of Manchester	·0369
Streets of Manchester	·0403
Open places of London	·0301
Streets of London	·0341
Lake of Geneva (Saussure's analysis) . .	·0439

It also appears that the air of the highest mountains contains more carbonic acid, less oxygen, and less organic matter, than the air of plains, and that the quantity of oxygen is always sensibly diminished in the air of towns.

The amount of aqueous vapour fluctuates greatly, and is mainly influenced by temperature. At a given temperature air cannot contain more than a certain quantity of moisture in suspension, and when it has taken up this quantity it is said to be saturated. In general, the air contains from 50 to 75 per cent of the amount requisite for complete saturation, the average amount being about 1·46 in 100 parts. If the quantity be not within these limits, the air is either unpleasantly dry or moist.

The ammonia, which exists as carbonate, chloride, sulphate, or sulphide, is present only in very minute quantities, and does not exceed one part in a million parts of air.

In addition to these ingredients, ozone may perhaps be reckoned as a normal constituent, and spectroscopic analysis has shown that the salts of sodium are everywhere present in greater or less abundance.

Section II.—Impurities in Air, and their Effects on Public Health.

Preliminary Remarks.—Impurities in air may be roughly divided into suspended and gaseous matters. While the presence of suspended matters is rendered familiar to every one in the shining particles which become visible in the direct rays of the sun, the late demonstrations by Professor Tyndall with the electric light have shown, perhaps more forcibly than hereto-

fore, their almost universal diffusion. Particles of silica and silicates, of calcium carbonates and phosphates, of iron salts, and, in short, of every chemical constituent of the soil, are lifted by the winds and carried hither and thither. In inhabited places, carbon particles, hairs, fibres of cotton, wool, and other fabrics, starch-cells, etc., are found in great abundance. From the vegetable world are wafted seeds and the *debris* of vegetation, as well as spores, germs, pollen, and volatile substances. In like manner, the animal kingdom supplies germs of vibriones, bacteriæ, and monads, and particles of decayed or decaying tissues, such as epithelium and pus-cells.

The numerous gaseous matters which pass into the atmosphere, and render it impure, will be more conveniently noticed in the subsequent remarks concerning overcrowding, and the injurious effects of different trades and manufactures.

But there are other organic vapours arising from the decomposition of vegetable and animal products which merit special attention, as, for example, those contained in the air of marshes and sewers. The exact chemical composition of these vapours still remains a mystery. Equally obscure too is the nature of those organic substances which constitute the specific poisons of contagious diseases. Whether they consist of inconceivably minute particles of decaying matter, or of living microscopic germs; whether, in some instances, they are conveyed by epithelium and pus-cells from the diseased to the healthy, or are condensed with the watery vapour of the atmosphere, and thus disseminated;—all these are questions which have yet to be satisfactorily answered. Certain it is, that in almost

all cases the atmosphere is made the vehicle of the contagium or morbific agent, whatever its nature; and hence the paramount importance of adopting such measures as will prevent contamination of the air; or, at all events, aid in dissipating or destroying its more noxious impurities. It is true, some of the operations of Nature are in themselves calculated to accomplish this end. Injurious gases become diffused, diluted, or decomposed; animal emanations are absorbed in the processes of vegetation; suspended matters are washed down by the rains, or fall by their own weight; while many organic substances are oxidised, and thus rendered innocuous. Were it not for these purifying agencies, which are in constant activity, sanitary measures would prove futile; and, indeed, they are only successful in so far as they approximate to the preventive and remedial means which Nature employs.

1. *Air vitiated by Respiration.*—The effete matters thrown off in respiration are carbonic acid, watery vapour, and certain undefined organic substances.

According to Dr. Carpenter, who has summarised the results obtained by various physiologists, an adult man, under ordinary circumstances, gives off 160 grs. of carbon per hour. In both sexes the amount increases up to about the thirtieth year, but beyond the eighth year the exhalation is greater in males than in females. Dr. Parkes gives the average amount of carbonic acid exhaled by an adult in the twenty-four hours as 16 cubic feet, or a little over ·6 cubic feet per hour.

The quantity of watery vapour thrown off by the skin and lungs varies according to the hygrometric condition of the atmosphere. It has been estimated

at from 25 to 40 oz. in the 24 hours, and requires, on the average, 210 cubic feet of air per hour to retain it in a state of vapour.

The organic matter given off has never been accurately determined. It has a very fœtid smell, and is but slowly oxidised. It is believed to be molecular, and may be said to hang about a room like clouds of tobacco-smoke, and, like tobacco-smoke, the odour is difficult to be got rid of, even after free ventilation has been resorted to. It darkens sulphuric acid, and decolorises solutions of potassium permanganate. When drawn through pure water it renders it very offensive. It is certainly nitrogenous, and probably in combination with water, because hygroscopic substances absorb it most readily. In sick-rooms it is associated with pus-cells and other emanations of disease. As much as 46 per cent of organic matter has been found in plaster taken from the walls of an hospital ward in Paris.

As the ammonia, and more especially the albuminoid, may be taken as an index of the amount of organic impurities contained in air collected at various places, the following summary of analyses, by Dr. Angus Smith, is instructive:—

Air obtained from	No. of Experiments.	Free Ammonia. Grains per Million cubic feet.	Albuminoid Ammonia. Grains per Million cubic feet.	Total Ammonia. Grains per Million cubic feet.
Innellan (on the banks of the Clyde) . . .	1	22·845	60·228	83·073
London . . .	18	26·780	65·947	92·727
Glasgow . . .	4	34·169	133·264	167·433
A bed-room . .	3	44·305	104·118	148·423
A midden . .	3	146·911	181·524	328·435

Practically speaking, the amount of organic matter

in air vitiated by respiration is found to increase as the carbonic acid increases. According to Dr. Parkes it becomes distinctly perceptible to the sense of smell when the carbonic acid, in an inhabited room, amounts to ·7 per 1000 cubic feet of air—a statement which has been frequently verified by other experimenters.

The effects of breathing considerable quantities of carbonic acid in air otherwise pure have not yet been determined with sufficient accuracy. Dr. Angus Smith has found that 30 volumes per 1000 cubic feet of air produced great feebleness of the circulation, slowness of the heart's action, and quickened respiration, but he experienced no discomfort in a soda-water manufactory, where the amount was 2 per 1000 volumes. On the other hand, Pettenkofer and Voit found that no discomfort was experienced from long exposure when as much as 10 per 1000 volumes was present. In respired air, however, headache and vertigo are undoubtedly produced in many persons when the carbonic acid exceeds 1·5 per 1000 volumes, but probably this is as much due to the presence of organic effluvia, and the diminution in the quantity of oxygen, as to the increase in the amount of carbonic acid. Yet it must be borne in mind that even a small excess of carbonic acid interferes with healthy physiological action, inasmuch as it prevents the sufficient exhalation of the gas itself, and induces an undue accumulation of it in the blood. In like manner, the quantity of oxygen absorbed is lessened, and there is consequently a retardation of those oxidising processes which are requisite for the complete elimination of effete matters from the system. But while there is always an increase in the amount of carbonic acid, there is likewise a marked diminution in

the quantity of oxygen in respired air. Thus, Dr. Angus Smith found that the percentage of oxygen in the open air of a suburb of Manchester amounted to 20·96; in a sitting-room, to 20·89; in the pit of a theatre, to 20·74; in the Court of Queen's Bench, to to 20.65; and in the sumpt of a mine, to 20·1400. It does not follow that, because pain or discomfort is not always experienced in a vitiated atmosphere, no harm has been done. The effects may be slowly and imperceptibly cumulative, but they are none the less injurious, and they are now recognised as being the most potent and wide-spread of all the "predisposing causes" of disease.

Speedily fatal results, arising from overcrowding and the want of fresh air, are familiar to every student of medicine. Out of the 146 prisoners confined in the "Black-hole of Calcutta," 123 died in one night: and it is significant that many of the survivors afterwards succumbed to "putrid fever." Nor have similar instances been wanting in this country. Of the 150 passengers that were shut up in the cabin of the Irish steamer *Londonderry*, with hatches battened down, during a stormy night in 1848, 70 died before morning. No doubt, in these two catastrophes, the direct cause of death was asphyxia, but the fact that "putrid fever" attacked many of those who were carried out alive from the Black Hole of Calcutta, showed that the fœtid exhalations to which they were exposed must have aided largely in destroying the lives of the immediate victims. Indeed, it is admitted by all physiologists that the re-breathing of fœtid matter thrown off by the skin and lungs, produces a kind of putrescence in the blood, in proportion to the amount inhaled and to the period of

exposure to its influences. Of this species of poisoning, the history of the "Black Assizes," in the sixteenth, seventeenth, and eighteenth centuries, furnishes many terrible examples. Jail, or typhus, fever, according to Dr. Murchison, was frequently generated *de novo* solely in consequence of the disastrous effects of overcrowding and deficient ventilation, and the disease thus generated often spread from the court-house, where the prisoners were tried, to the surrounding population. "My reader," said John Howard, "will judge of the malignity of the air in gaols, when I assure him that my clothes were, in my first journeys, so offensive, that in a post-chaise I could not bear the windows drawn up, and was therefore often obliged to travel on horseback. The leaves of my memorandum-book were often so tainted that I could not use it until after spreading it an hour or two before the fire." Even so late as 1815, Harty showed that typhus was being constantly generated in the prisons of Dublin whenever they became overcrowded with convicts prior to the periodical transportation of the accumulated numbers to a penal settlement. Or, to come to more recent times, one finds Dr. Buchanan reporting to the medical officer of the Privy Council regarding an extensive epidemic in Merthyr-Tydfil in the beginning of 1870, that it was true typhus fever, and that he referred it to overcrowding, and to want of ventilation in the houses of the poorer people.

Such are some of the more direct and palpable effects of overcrowding and deficient ventilation; but there are others, perhaps equally grave, though not so well pronounced, which cannot be overlooked. All the so-called zymotic diseases, for example, are more spe-

cially fatal, and spread with the greatest virulence, in densely populated and badly ventilated districts, and it is in these "fever-nests" that epidemic diseases, which prevail during certain septic conditions of the atmosphere, are attended with the highest mortality and the greatest sick-rate.

Of other diseases developed by respired air, there can be no question that phthisis pulmonalis holds a prominent place on the list. A large mass of evidence has been collected from various sources bearing on this point, but the fact is now so fully recognised by the medical profession generally that a few instances will suffice. In the celebrated report of the Army Sanitary Commission, published in 1858, it was proved beyond all doubt that the excessive mortality from consumption amongst soldiers, and in particular regiments, was due to overcrowding and insufficient ventilation. Previous to that inquiry, the cubic space per soldier in the barracks of the Foot Guards only amounted to 331 cubic feet, and the phthisis mortality was as high as 13·8 per 1000. In the Horse Guards, on the other hand, with a space per man of 572 cubic feet, the mortality from phthisis did not exceed 7·3 per 1000. It was found that phthisis prevailed at all stations, and in the most varied and healthy climates, the vitiated air in the barracks being the only condition common to all of them. In consequence of this excessive mortality, the Commissioners recommended that the cubic space allowed per man in barracks should be increased, and the ventilation improved, with the result that, from the time their recommendations were acted upon, the number of phthisical cases occurring at all these stations has materially diminished.

Similar evidence is afforded by the statistics of the Royal Navy, and notably as regards the civil population, in the Report of the Health of Towns Commission, published in 1844. Indeed, it has been fully established that not only phthisis, but other lung affections, such as pneumonia and bronchitis, are generated to a large extent under like conditions, and the same may be said of such diseases as scrofula, and others of an adynamic type.

When air is vitiated by the exhalations of the sick, as in hospitals, there is a risk of gangrene and erysipelas spreading, especially in the surgical wards. The period of convalescence, in many cases, is retarded, and the mortality rate increased. Pus-cells and putrefying particles are thrown off from purulent discharges, and finding a suitable nidus elsewhere, may communicate a special disease, and thus act as a true contagium. The prevalence of purulent ophthalmia, under certain conditions, and the spread of lung-disease in badly ventilated ships, when the disease appeared to be propagated from person to person, can only be fully explained on some such theory as this.—(*Parkes.*)

2. *Air rendered Impure by Sewage and Cesspool Effluvia.*—Amongst the gases generated by the decomposition of fæcal matter, whether occurring in sewers or cesspools, may be enumerated, carbonic acid, nitrogen, sulphuretted hydrogen, light carburetted hydrogen, and ammonium sulphide. Dr. Letheby found that sewage-water, excluded from air, and containing 128 grs. of organic matter per gallon, yielded 1·2 cubic inches of gas per hour during a period of nine weeks. But the amount of gaseous products given off under ordinary circumstances must vary greatly, according to the

dilution of the sewage, the rapidity of flow, temperature, ventilation of the sewers, etc. In comparing the results of analyses made by various chemists, it would appear that the oxygen is diminished, and the carbonic acid greatly increased, but that sulphuretted hydrogen and ammonium sulphide, when present, exist only in very small quantities. The peculiarly fœtid smell of sewage-gas is therefore owing to the presence of organic matter, whose exact chemical composition, however, has not been determined. Dr. Odling believes it to be carbo-ammoniacal. It is alkaline in reaction, and speedily decolorises solutions of potassium permanganate. Like other organic effluvia, it promotes the growth of fungi, renders milk sour, and taints meat.

It is doubtful whether the effects of sewer-air upon the health of men employed at work in sewers can be said to be very injurious. Indeed, the researches of Dr. Guy and Parent du Chatelet, at first sight, go to prove that this class of labourers enjoy a marked immunity from diseases which can be attributed to sewer-emanations; but, as has been shown by Dr. Murchison, there are several elements of error in their statistics which mar their conclusions. For example, Dr. Guy's researches were made before enteric and typhus fever were fully recognised as distinct diseases, and Parent du Chatelet's statistics were not only too scanty for a fair deduction, but the majority of the sewer-men whom he examined had been employed at that special work for only a short period. According to Dr. Murchison's experience, enteric fever is by no means uncommon among these men, and Dr. Peacock's inquiries led him to express a similar opinion. But whatever the issue of this question, it seems to be quite certain that con-

stant exposure to sewer-gases diminishes the risk of being injured by them. A remarkable instance of this apparent immunity enjoyed by workmen, and the disastrous effects upon those whose exposure to such gases was only casual, is afforded by an event that occurred at Clapham in the autumn of 1829:—20 out of 22 boys at the same school were seized with violent vomiting, purging, prostration, and fever, within three hours. One boy had been seized with similar symptoms two days before, and died; another also succumbed. So alarming was the outbreak that poisoning was suspected, but, after careful investigation, it was found that the sole cause of disease was to be attributed to the opening of a drain at the back of the house. This drain had been choked up for many years, and had been opened two days before the first illness occurred. The effluvia from the drain were most offensive, and the boys had watched the workmen cleaning it out; none of the workmen, however, were subsequently attacked with any of the symptoms which so seriously affected the boys.—(*Murchison.*)

A similar instance, with more disastrous results, is recorded as having taken place only a short time ago. All the hands employed in the winding-room of one of the mills at Swillbrook, Preston, were suddenly seized with symptoms of alarming illness. At first it was supposed that the illness was caused by minute particles of dye thrown off by some coloured yarns, but it was soon discovered that the air of the apartment was contaminated with mephitic gases issuing from a drain which emptied itself into an adjoining water-course. The drain had become blocked up in consequence of a "fresh" in the river, arising from heavy rains, and in

this way the sewage was allowed to accumulate. Several of those who were attacked died, and others were seriously ill for some time.—(From *Food, Water, and Air.*)

While numerous other instances are recorded of the evil effects of the air of sewers, cesspits, drains, etc., in producing temporary ailments, such as nausea, vomiting, diarrhœa, and headache, the great interest which attaches to this important subject rests on the development and spread of enteric fever. Dr. Murchison, in summing up his evidence with regard to the spontaneous origin of this disease, says, "I readily admit that we cannot succeed in tracing every case of enteric fever to organic impurities. But if the disease can be traced to such causes, in a few undoubted instances, it is reasonable to infer that its causes are similar in all cases where it has a spontaneous origin. As already stated, the actual poison may, like the miasmata which give rise to ague, be inappreciable to the senses, or by chemical research. During the last four years (1858-1862), however, I have met with few examples of enteric fever which, on investigation, I could not trace to defective drainage, the existence of which was occasionally unknown to the inhabitants of the infected locality."

More recent researches tend to show that enteric fever is perhaps seldom generated *de novo*, but that it is essentially a specific and infectious disease. No doubt, a great deal of the discrepancy of opinion which has hitherto existed, and still exists, concerning its etiology, is due to the difficulty of diagnosing the many different varieties of the disease. The point, however, which has especially to be borne in mind is this,—that sewers often become the real channels by which the contagium is

propagated. The sewer-air, laden with the specific poison, readily finds its way into houses on account of its greater tension, and in consequence of badly-trapped or imperfectly-ventilated drains. It may be inappreciable to the senses, but its baneful effects make themselves felt none the less, and, as recent events have shown, may sometimes exhibit themselves in the most exalted stations of life. Indeed, it would appear that persons of the upper and middle ranks in towns are more liable to be attacked by enteric fever than the poorer classes, and for this reason—the houses of the former are more generally connected with sewers, and, either from structure or situation, are of higher elevation, so that the light sewer gases, in obedience to natural laws, are more apt to accumulate in the drains of such houses, and when the drains are not efficiently trapped or ventilated, to effect an entrance into the houses themselves. Thus it happens that a system of sanitary engineering which is intended to prevent, and does prevent, the development of disease, not unfrequently furnishes the readiest means for its propagation. All this, however, could be frustrated if sewers and drains were always properly ventilated.

One other point connected with the propagation of enteric fever deserves notice :—it seems to be clearly established that the disease may be contracted by inhaling the effluvia from enteric stools previous to their being disposed of, and hence the necessity of disinfecting all such stools so soon as they are passed.—(*Parkes.*)

Amongst other serious consequences of fæcal emanations, the occasional spread of cholera, and the occurrence of autumnal diarrhœa, are specially to be noted.

The outbreak of cholera in the City of London Workhouse, in July 1866, was shown by Mr. Radcliffe (*Ninth Report of Medical Officer of the Privy Council*) to have taken place, in all probability, in consequence of a sudden efflux of sewer-air from a drain containing choleraic evacuations. Autumnal diarrhœa, again, is found to prevail when the season is warm and dry, and more particularly in badly-sewered districts. In speaking of this subject, Dr. Murchison says, that "circumscribed autumnal epidemics of enteric fever are often preceded by an increase of diarrhœa, and the diarrhœa reaches its acme long before the fever does." After heavy falls of rain the sewers become well flushed, and the diarrhœa subsides.

According to the evidence of Sir Henry de la Beche and Dr. Lyon Playfair, in the Second Report of the Health of Towns Commission, there are strong presumptive grounds for believing that emanations from streams polluted by fæcal matter may be injurious to the health of inhabitants living on their banks. It is stated that many of them were pale, and suffered from dyspepsia, and that cases of fever, when they occurred, were increased in severity. In other instances, however, no such effects have been traced.

When sewage matter is thrown over the ground, or allowed to sink into the soil as in sewage irrigation, the exhalations given off have likewise been proved to be sometimes productive of serious disease. Thus, Dr. Clouston has recorded an outbreak of dysentery among the patients in the Cumberland and Westmoreland Asylum, which he attributed to the emanations from sewage applied to the land about 300 yards from the asylum. After this outbreak the sewage was allowed to fall into a

small stream, and for two years the asylum had been free from the disease. At the end of this period, however, the sewage was again applied to the farm, and again the dysentery appeared, although all proper precautions were taken in the way of disinfecting and in applying the sewage. It is to be noted that there was a stiff brick-clay subsoil, and doubtless this prevented the sufficient percolation of the sewage into the ground. (For further observations on this point, see Chapter XII.)

3. *Effluvia from decomposing Animal Matter.*—Under this heading may be included—the effluvia from decomposing carcases; the air of graveyards; and the effluvia from manure, tallow, and bone-burning, manufactories.

On almost all these points the evidence is very conflicting. The preponderance of opinion, however, leaves no room for doubt that the effects of all such effluvia upon the health of the general population, when exposed to their influence, are more or less injurious; and in support of this view the following, amongst many other confirmatory instances, may be quoted:—

(1.) The effluvia arising from the putrid remains of horses killed on the field of battle have frequently given rise to outbreaks of diarrhœa and dysentery amongst the soldiers. In the French camp, before Sebastopol, when numbers of the bodies of horses lay putrefying and unburied, the effects were so serious that the spread of typhus was supposed to be due to this cause. (*Parkes.*)

(2.) According to the evidence summed up in the Report on Extramural Sepulture in 1850, the vapours given off from thickly-crowded graveyards, if not actually productive of disease, do certainly increase the sick and death-rate of the immediate neighbourhood.

(3.) Although the health of workmen employed in manure and similar manufactories does not appear to be injured by their occupation, the occasionally disastrous effects upon others, of the effluvia given off, are well illustrated by the following case:—In 1847, many of the inmates of Christ Church Workhouse, Spitalfields, were seized with violent attacks of diarrhœa, of an enteric type. It was found that whenever the works were actively carried on, and particularly when the wind blew from that quarter, there ensued an outbreak of diarrhœa in the workhouse. In December of the following year, when cholera was spreading in the neighbourhood, sixty of the children were attacked one morning with violent diarrhœa. In consequence of this outbreak the owner of the manufactory was obliged to stop work, and the children rapidly recovered. Five months afterwards the works were resumed, and again there was a similar outbreak amongst the inmates occupying the part of the building opposite the manufactory. The works were once more discontinued, and the diarrhœa ceased. (*Carpenter.*)

The effluvia produced in tallow-making and bone-burning, though sometimes very offensive, and therefore an undoubted nuisance in inhabited districts, do not appear to have produced any serious effects which have been recorded. Owing to their being slowly oxidised, such vapours may be detected at very long distances. (*Parkes.*)

4. *Gases and Vapours given off by Alkali Works, Chemical Works, and Brickfields.*—(1.) The principal gas evolved in alkali works is hydrochloric acid. Its effects on vegetation are so destructive, that an Act was recently passed to ensure more thorough

condensation of the acid gas given off. This condensation is now carried on with such completeness in most works, that the escaping gases do not cause a turbidity in a solution of silver nitrate, thereby showing that no trace of the acid gas is present. (*Roscoe.*)

(2.) From chemical works, and especially from those in which gas-liquor is utilised for the production of salts of ammonia and other chemical compounds, the injurious gases evolved consist chiefly of sulphuretted hydrogen, ammonium sulphide, and traces of other ammonium compounds. The workmen employed at such works apparently enjoy good health, but when the noxious vapours are not properly consumed by being collected and passed through a furnace, there is no doubt that they do affect the health of the neighbouring inhabitants, though not to any serious extent. In a case tried not long since at Portsmouth, several witnesses gave evidence that they often suffered from nausea, vomiting, and headache, when the wind blew from the direction of chemical works of this description, although some of them lived at over a mile's distance from the works. It is probable, however, that these effects were partly to be attributed to the effluvia of a knackery and manure-manufactory, situated within 300 yards of the works.

(3.) The peculiarly pungent odour of brickfields can be felt at several hundred yards' distance; but though several cases are recorded, in which the existence of a nuisance was fully established, none are quoted as having proved that the health of the neighbourhood was affected.

5. *The Air of Marshes.*—This generally contains an excess of carbonic acid, light carburetted hydrogen,

watery vapour, sulphuretted hydrogen, and organic effluvia. It also abounds with the *debris* of vegetable matter, infusoriæ, and insects.

The more serious and characteristic effects of marsh miasmata, are intermittent and remittent fevers. Ailments, however, of a less severe nature—such as diarrhœa, dysentery, and various other gastric derangements—have been attributed to their influence; and even when no marked signs of disease can be detected, the inhabitants of such districts often present an enfeebled and pallid appearance. The submerging of meadows, draining of lakes, and digging of canals, have all of them been followed by the development of marsh diseases, probably on account of the decomposition of vegetable matter which ensues. For the same reason, a long continuance of dry weather, followed by rains, favours the evolution of miasmata. Fortunately, in this country, marsh-diseases have become comparatively rare, though there is no doubt that in low-lying and badly-drained districts, the excessive sick-rate which often prevails is in a great measure owing to atmospheric impurities of a marshy nature.

6. *Air-Impurities in certain Trades and Occupations.*—The deleterious impurities under this heading consist chiefly of mineral and organic substances, as, for example, the particles of coal-dust in the air of mines; particles of steel and grit given off in grinding; arsenical fumes, in copper-smelting; zinc fumes, in brassfounding; pearl-dust, in button-making; organic dust or fluff, in shoddy and flax mills, etc. But the whole of this part of the subject is so extensive, that only a few instances of the increased sick-rate and mortality produced by these impurities can be given here.

The habitual inhalation of coal-dust contained in the

air of coal-mines results in what is called the "black-lung," the pneumonic cells becoming gradually blocked up, so that, after death, the lung presents a peculiarly melanotic appearance. Cases of emphysema and chronic bronchitis are also very common amongst colliers, and it has been ascertained that the aggregate amount of sickness experienced by this class of workmen between the ages of 20 and 60 amounts to 95 weeks, or 67 per cent more than the general average. (*Wynter.*) No doubt much of the disease with which miners are liable to be attacked is to be attributed to the baneful effects of inhaling the products of combustion given off by candles, lamps, etc.; because, when mines are well ventilated, as in Durham and Northumberland, lung affections are much less frequent.

The following table, quoted by Dr. Parkes, shows the enormous increase of pulmonary disease amongst workmen employed in metalliferous mines after the age of 35:—

Average Annual Deaths per 1000, *from Pulmonary Disease, during the Years* 1860-62 *inclusive.*

Ages.	Metal Miners in Cornwall.	Metal Miners in Yorkshire.	Metal Miners in Wales.	Males, exclusive of Miners in Yorkshire.
Between 15 and 25 years	3·77	3·40	3·02	3·97
„ 25 „ 35 „	4·15	6·40	4·19	5·15
„ 35 „ 45 „	7·89	11·76	10·62	3·52
„ 45 „ 55 „	19·75	29·18	14·71	5·21
„ 55 „ 65 „	43·29	41·47	35·31	7·22
„ 65 „ 75 „	45·04	53·69	48·31	17·44

But of all unhealthy occupations that of steel-grinders is perhaps the most fatal. Steel-grinding is divided into dry, wet, and mixed; the injurious effects varying

according to the amount of water used on the stone. Forks, needles, backs of scissors, etc., are all ground on the dry stone, and, accordingly, the men and boys employed at this kind of work suffer most. Dr. Hall of Sheffield has collected a large amount of information bearing upon this subject, from which the following particulars relating to the average duration of life of artisans in steel have been summarised by Dr Wynter:—"Dry-grinders of forks, 29 years; razors, 31 years; scissors, 32 years; edge-tool and wool-shears, 32 years; spring-knives, 35 years; files, 35 years; saws, 38 years; sickles, 38 years." Fans, however, are now more commonly used than formerly, and wet-grinding is becoming more general, so that it is to be hoped the average longevity of Sheffield grinders is increasing.

In the pottery trade, the flat-pressers and scourers suffer to such an extent from the effects of the fine dust inhaled, that, according to Dr. Greenhow, almost all of them become eventually asthmatical.

Pearl-button makers, and workers in flax or shoddy mills, are all afflicted more or less with bronchial irritation, and many of them with decided lung-disease. Cotton-weavers also suffer very much from the fine dust given off by the "sizing;" and recently an inquiry was made by Dr. Buchanan at Todmorden, which revealed the great prevalency of lung-disease, dyspepsia, and permanent epistaxis, amongst this class of operatives.

In addition to asthma and bronchitis, brassfounders are very liable to attacks of an affection called "brassfounders' ague," the characteristic symptoms of which present themselves in the following sequence:—shivering, nervous depression, marked febrile disturbance, and profuse sweating.

Workers in lead are apt to suffer from "drooping wrist" and lead colic; lucifer-match makers, from necrosis of the lower jaw, caused by phosphorous fumes; and workers in mercury, from mercurialism.

In the Third Report of the Medical Officer of the Privy Council, Dr. Greenhow gives the following summary of his inquiry into the excessive mortality from lung-diseases :—

"This inquiry has demonstrated that an excessive prevalence of pulmonary diseases is associated with a great variety of conditions, some of which must clearly be regarded as exciting causes of these diseases. With respect to others, it has been found impossible to obtain accurate and conclusive evidence that they produce diseases of the lungs, but there are strong grounds for supposing such to be the case. There is also a third class of conditions, on which great stress was laid by various medical practitioners, and which may perhaps be regarded as having a tendency to produce these diseases. The conclusions deducible from the inquiry may therefore be arranged under the three following heads :—

"A. Conditions which this inquiry has shown to be direct causes of pulmonary diseases.

"B. Conditions so frequently associated with an excessive pressure of pulmonary diseases, that they may be regarded as at least indirect causes of these diseases.

"C. Conditions which, in all probability, co-operate in producing pulmonary diseases, but respecting the influence of which no conclusive evidence could be obtained."

"A. 1. Inhaling an atmosphere loaded wirh mecha-

nical impurities, such as fine dust of metal, stone, clay, or of certain animal and vegetable products ; soot, and particles of flax, cotton or woollen fibre, exemplified in the case of grinders of cutlery, needles, and other steel articles ; miners, quarrymen, stonemasons, china-scourers, potters, turners of earthenware, makers of plaster-of-Paris moulds, hacklers of flax and Mexican fibre ; sorters of wool, alpaca, and mohair ; operatives employed in the manufacture of waste silk, and in the carding-rooms of cotton factories ; wool-combers ; workers in bone, ivory, horn, and mother-of-pearl; and makers of walking-sticks, and wooden handles for cutlery, umbrellas, and parasols.

"2. Inhaling an atmosphere containing carbonic acid or other gases unfit for respiration, or fumes arising from the combustion of gunpowder, or of charcoal, or other fuel, exemplified in the cases of miners and wool-combers.

"3. Inhaling an overheated and highly-dried atmosphere, exemplified in the cases of the flat-pressers, and some other workers in potteries.

"B. 1. Habitual exposure, during the hours of labour, to a hot and exceedingly moist atmosphere, exemplified in the cases of slip-makers in potteries and spinners of flax.

"2. Working in ill-ventilated and over-heated factory-rooms, as in many manufactories of textile fabrics, in some of the decorators' rooms of potteries, in warehouses, and likewise in many establishments where young females are congregated together at work.

"3. Exposure to vicissitudes of temperature, exemplified in the cases of the operatives in several kinds of factories and workshops.

"4. A stooping or otherwise constrained posture while at work, exemplified in lace-makers, throwers of earthenware, certain classes of weavers, file-cutters, and silk-piercers.

"5. Working continuously many hours daily at a sedentary occupation, such as that of the glove-makers of Yeovil, decorators of earthenware, and welters and finishers of hosiery.

"6. Working in ill-ventilated and over-crowded rooms, as in the straw-plat and lace schools of Berkhamstead, Towcester, and Newport Pagnell, the winding rooms of Leek, and the weaving shops of Hinckley and Leicester.

"7. Residing in dwellings so constructed that the bedrooms are badly ventilated, and the cubical space per head is inadequate to the preservation of health, such as are to be found in Berkhamstead and Saffron Walden.

"C. 1. Bleakness of climate, a cold damp soil, prevalence of fogs.

"2. Marriages of consanguinity.

"3. Habitual abuse of alcoholic stimulants.

"4. Insufficiency of animal food."

Although certain parts of this summary have no immediate connection with the subject-matter in hand, it has been given *in extenso*, to show how frequently several causes of disease co-operate in producing the same pathological results, and how difficult it is to apportion to these causes their relative share in the combined effects. But, apart altogether from the unwholesome influences attaching to particular employments, the one great fact which stands forth with special

prominence throughout the whole of Dr. Greenhow's inquiry (see also *Fourth Report to Privy Council*), is the fatally defective state of the ventilation, alike of cottage, workroom, and of busy factory. The mortality from lung-disease amongst male and female operatives was found to be from three to six times as great as in other districts of England; and in a very large proportion of cases the want of ventilation in dwelling-places, as well as work-places, prevailed to such an extent, that tubercular and scrofulous diseases must have resulted abundantly from this cause alone.

The medical officer of the Privy Council, in commenting on this inquiry, remarks—"One must remember that, in most cases, either the artisan's ill-ventilated work-place is also his ill-ventilated dwelling-place, or else the dwelling-place to which he goes for his rest is as ill ventilated as the work-place which he leaves; that during a great part of the year the work-place has artificial light in it, in many cases gaslight for some hours of the day, and in some cases has its atmosphere vitiated by other products of combustion; that in factories during winter the commonly adopted method of warming is one which in itself makes the air unpleasant, if not hurtful for breathing; and that in many branches of industry good ventilation is essential as a safeguard against evils which are special to the employment—essential for the removal of injurious dust, or for the abatement of an oppressive temperature."

In all these industrial employments it thus appears that the sick-rate and death-rate could both be very materially lessened by promoting ventilation, and by introducing some suitable appliances calculated to protect the workmen from the inhalation of fine dust or

noxious fumes. But it was found that the workmen themselves often objected to any innovation which appeared to them to interfere with their more immediate comfort; and not a few of them were under the impression that the introduction of any measures tending to prolong life would be followed by such an overstocking of the labour market, that the difficulties of procuring a living would be greatly increased. That such short-sightedness will continue to exist amongst certain numbers of the artisan class is only what may be expected. Disease sets in so insidiously and progresses so slowly, the stock of health to start with seems so ample, and the individual prospect of death so remote, that sanitary rights are neglected and the wrongs quietly endured. Hence the remedy for such wide-spread evils must be supplied from without,—by rigorous sanitary inspection under the provisions of sanitary laws. (See concluding Chapter and Appendix.)

CHAPTER IV.

VENTILATION AND WARMING.

These two subjects may be conveniently treated under the following sections:—

I. The Amount of Fresh Air required.
II. The Necessary Amount of Cubic Space.
III. Natural Ventilation.
IV. Artificial Ventilation and Warming.

Section I.—The Amount of Fresh Air required.

As the air contained in an inhabited room cannot, under the most favourable circumstances, be maintained in as pure a condition as the external air, the object of ventilation is to reduce the impurities of respiration to such an extent that continued inhalation of them will not be detrimental to health. While this can only be effected by a constant supply of fresh air, it is evident that the quantity required will very much depend on the amount of impurities which may be allowed to accumulate in respired air without proving injurious. The first point, therefore, which has to be determined, is the limit of maximum impurity consistent with the maintenance of perfect health. It has already been shown that the amount of carbonic acid in air vitiated by respiration is a tolerably reliable index to the other impurities; and hence the question resolves itself into this,—What amount of carbonic acid shall be accepted

as the standard of permissible maximum impurity? After numerous experiments and a most extended inquiry, Dr. Parkes has given it as his opinion that, allowing ·4 volume as the average amount of carbonic acid in 1000 volumes of air, this standard ought not to exceed ·6 per 1000 volumes; because, when this ratio is exceeded, the organic impurities, as a rule, become perceptible to the senses. With a ratio of ·8, ·9, or 1 per 1000 volumes, the air smells stuffy and close, and beyond this it becomes foul and offensive. Dr. Parkes observes, "I admit that I am not able to show, by direct evidence, that impurity indicated by ·7, or ·8, or even 1 volume of carbonic acid per 1000, and organic impurities in proportion, is injurious to health. We possess no means of testing the effects of such small quantities. Such a standard must be adopted, first, on the general evidence that large aerial impurities are decidedly hurtful, and that smaller amounts may be presumed to be so in proportion, although we cannot measure the action; and, secondly, on the fact that we have an obvious and simple measure in the effect produced on the senses, which gives us a practical line of demarcation we could not otherwise obtain." (*Practical Hygiene.*)

Perhaps there is no class of buildings which present better opportunities for arriving at an approximate and practical solution of this problem than prisons; and it may prove of some service if I record briefly the results of some experiments which I have had a share in conducting, and which are strongly corroborative of Dr. Parkes' views.—In one of the convict prisons, one-half the prisoners are kept in separate confinement except when at exercise, the other half are confined in their cells only during the night and when at meals. The

cubic space and ventilating arrangements in the part of the prison occupied by the former, were such, that the average ratio of carbonic acid, after a series of observations made at different hours of the night, was found to be ·720 per 1000 volumes; while in the part of the prison occupied by the latter, the cubic space was much smaller, and the average amount of carbonic acid was as high as 1·044 per 1000 volumes. The same number of observations were made in both parts of the prison at the same hours during the night-time, so that a strictly fair comparison could be drawn. Now, a careful inspection of the two classes of prisoners resulted in showing that whereas the former were well nourished and healthy-looking, the latter presented a somewhat less robust and more pallid appearance; and, after eliminating every source of error, this difference in appearance could only be accounted for by the difference in the amount of impurities contained in the respired air of both parts of the prison.

I have had many other opportunities of examining into this point, and would say, in general, that when the carbonic acid does not exceed ·8 per 1000 volumes, no *tangible* injurious effects upon the health can be detected; but when it reaches 1 per 1000 volumes, the cumulative effects manifest themselves in producing a pallid dyspeptic appearance, and make themselves felt, in numerous instances, in general *mal-aise* of a morning, slightly coated tongue, nasty taste in the mouth, and headache.

The desirability of adopting Dr. Parkes' estimate as the standard of maximum impurity is also borne out by the observations and experiments of such eminent authorities as Professor Pettenkofer of Munich, Dr.

Angus Smith, and Dr. de Chaumont. "We all avoid," says Dr. Smith, "an atmosphere containing ·1 per cent of carbonic acid in crowded rooms; and the experience of civilised men is, that it is not only odious but unwholesome. When people speak of good ventilation, they mean, without knowing it, air with less than ·07 per cent of carbonic acid. We must not conclude that because the quantity of carbonic acid is small, the effect is small; the conclusion is rather that minute changes in the amount of this acid are indications of occurrences of the highest importance." (*Air and Rain.*)

Assuming, then, that ·6 carbonic acid per 1000 volumes is accepted as the standard of maximum impurity, the next question comes to be,—How much fresh air must be supplied per head per hour, in order that the respired air should not contain impurities in excess of this standard? It has already been stated, in the previous chapter, that an adult man exhales on the average ·6 cubic foot of carbonic acid per hour, and taking the initial carbonic acid contained in the atmosphere at the normal ratio of ·4 per 1000 volumes, the quantity of fresh air which should be supplied is found by calculation to amount to 3000 cubic feet per head per hour, in all cases in which the diffusion of the contained air is uniform. Of course, if a standard not so pure is fixed upon, the amount of fresh air required would be proportionately less. Thus, supposing the limit of maximum impurity to be ·7 carbonic acid per 1000 volumes, the amount required would be 2000 cubic feet; if ·8, 1500 cubic feet; and ·9, it would be 1200 cubic feet per head per hour. It is evident also, that women and children would require a smaller supply than men, because they do not vitiate the air so rapidly.

The results obtained by actual experiment accord so closely with those which have been deduced from mathematical calculation, that some of them may be fitly quoted here. The following are given by Dr. de Chaumont (*Edin. Med. Journal,* 1867) as selections from a series of observations made at Aldershot camp :—In a room containing 18 men, with a supply of 1200 cubic feet of fresh air per head per hour, the carbonic acid was found to be ·855 per 1000 volumes; in another containing 13 men, with a supply of about 1700 cubic feet, it was ·759 per 1000 volumes; and in a third, containing 22 men, and with a supply of about ·765 cubic feet per head per hour, it amounted to 1·2 per 1000 volumes. All these observations were made at the same hour (5 A. M.), and in barrack-rooms ventilated on the plan proposed by the Barrack Commissioners in 1861, which provided that at least 1200 cubic feet of fresh air should be delivered per head per hour.

But there are other circumstances in which it is necessary to augment the delivery of fresh air, in order to maintain the standard of purity. When lights are used, for example, and the products of combustion are allowed to pass into a room, a large supply is required to keep the contained air sufficiently diluted. Thus it is found that 1 cubic foot of coal gas destroys the oxygen of 8 cubic feet of air in combustion, and produces about 2 cubic feet of carbonic acid besides other impurities. As a common gas-burner burns about 3 cubic feet of gas per hour, the importance of having these deleterious products of combustion carried off by special channels will be readily admitted.

It is evident also that the sick require a larger supply of fresh air than the healthy, for it has been found

that when as much as 3500 to 3700 cubic feet have been delivered per patient per hour, hospital wards have not been free from offensive smell. Indeed, no greater proof can be afforded of the value of pure air than the excellent results obtained in surgical cases in times of war, and in medical cases when epidemics are raging, by exposing patients as much as possible to the external air.

Section II.—Cubic Space.

This should be large enough to permit the passage of 3000 cubic feet of air per head per hour, without producing perceptible draughts. If the cubic space per head is small, the renewal of air will necessarily be much more frequent than when it is large. Thus, with a space of 100 cubic feet, the contained air must be renewed thirty times per hour, in order that the standard amount be supplied; whereas, with one of 1000 cubic feet, only three renewals of air would be required. What, then, is the minimum amount of cubic space through which the standard amount of fresh air can be passed without perceptible movement? Professor Pettenkofer has answered this question experimentally, and has found that by means of artificial ventilation, and with the aid of the best mechanical contrivances, the air in a chamber of 424 cubic feet can be renewed six times per hour without creating any appreciable air-currents. No doubt, therefore, such a space as this, or one somewhat smaller, can be efficiently ventilated, provided that perfect artificial means be employed, and the air warmed, but with natural ventilation this becomes impossible. Indeed, Dr. Parkes maintains that a change of air four or three times per hour is all that can be

borne in this country, and this would require an initial air-space of 750 to 1000 cubic feet. Practically speaking, the difficulties of ventilating small spaces efficiently are due not so much to the movement of the contained air as to the relative position of the inlets, these being of necessity so near the person that the draughts which are produced become disagreeable or injurious. This is well exemplified in the case of prisons. In hard-labour prisons, where convicts are confined in their cells only during the hours of rest, the cell-space seldom exceeds 200 cubic feet. The consequence is that in cold or inclement weather these draughts become so unpleasant that many of the prisoners block up the inlets as effectually as they can, and of course obstruct the ventilation to a serious extent. So far as my experience goes, it is difficult, even with the aid of a well-devised plan of ventilation, to supply the necessary amount of fresh air per head per hour without creating perceptible draughts, if the space be less than 600 cubic feet. I have further satisfied myself that with the same artificial appliances and arrangements, the air contained in small occupied spaces becomes much more impure than in large spaces. For example, in the experiments already alluded to in the last chapter, the cell-space in one-half the prison was 210 cubic feet, in the other half it was 614. The same means for extracting the foul air through flues leading from every cell to a foul-air extraction shaft, in which a furnace was kept burning to produce a constant draught, were common to both parts of the building. Moreover, the fresh-air inlets were more amply provided for in the small than in the large cells, and yet the average amount of carbonic acid, after a series of observations, was found to be 1·044

per 1000 volumes in the former, and only ·720 in the latter.

With a small cubic space it is impossible to obtain uniform diffusion of the contained air, if a large amount of fresh air is supplied, because between inlet and outlet a direct current is established, and a considerable quantity of air passes right through without being utilised. Again, it is evident that if the ventilation is impeded or becomes arrested, impurities will collect with far greater rapidity in a small than in a large space, and this of itself is a great argument in favour of the adoption of an ample cubic space as a basis. Dr. de Chaumont, in his remarks on this point, writes :— " Let us suppose two occupied spaces, one of 500 and the other 1000 feet, ventilated so that the ratio of carbonic acid is ·06 per cent, and that from some cause or other the ventilation is arrested in both, the condition will then be as follows :—

" 1000 feet " Ratio of impurity.		" 500 feet " Ratio of impurity.	
" After one hour .	·12 per cent.	" After one hour .	·18 per cent.
,, two hours .	·18 ,, ,,	,, two hours .	·30 ,, ,,
,, three ,, .	·24 ,, ,,	,, three ,, .	·42 ,, ,,
,, four ,, .	·30 ,, ,,	,, four ,, .	·54 ,, ,,
,, six ,, .	·42 ,, ,,	,, six ,, .	·78 ,, ,,
,, seven ,, .	·48 ,, ,,	,, seven ,, .	·90 ,, ,,"

With ordinary means of ventilation (artificial excluded), both Dr. Parkes and Dr. de Chaumont maintain that the cubic space for a healthy adult ought at least to be 1000 feet. It is true this is very much in excess of what is generally obtained. In the crowded dwellings of the poorer classes it seldom exceeds 200 to 250 cubic feet; but then the disastrous effects de-

clare themselves but too clearly in the increased rate of mortality. In metropolitan lodging-houses the allowance per head is as low as 240 cubic feet; and in the Dublin registered lodging-houses it is 300. The Barrack Commissioners, on the other hand, recommended a minimum space of 600 cubic feet for soldiers, insisting at the same time that the air should be renewed at least twice every hour. "The only safe principle," they said, "in dealing with the subject is to have a large margin for contingencies; and the question really is, not whether 600 cubic feet per man be too much, but whether 600 cubic feet per man be enough for all the purposes of warming, ventilation, and comfort." Experiments that have since been made, and particularly those conducted by Dr. de Chaumont, prove most incontestibly that even this comparatively large allowance is inadequate for these purposes; but it was as much as could be obtained at the time, without putting the country to enormous expense. The Commissioners themselves observe:—"It has been said that the question of cubic space is simply a question of ventilation, but it is rather a question as to the possibility of ventilation. The more beds or encumbrances you have in a room, with a limited cubic space, the more obstruction you have to ventilation; the fewer the beds the more easy is it to ventilate the rooms. There are fewer nooks and corners, fewer surfaces opposed to the movement of the air, and less stagnation. We have been in rooms, both in barracks and hospitals, in which the atmosphere was positively offensive with the doors and windows open."

For further remarks on cubic space in hospitals, see chapter on hospitals.

In summing up this part of the subject, the following may be accepted as the standard conditions necessary for the requirements of *perfect* health :—

1. That the limit of maximum impurity of air vitiated by respiration ought not to exceed ·6 carbonic acid per 1000 volumes.

2. That to ensure the maintenance of this standard under ordinary circumstances, 3000 cubic feet of pure air must be supplied per head per hour.

3. That for this purpose, and with ordinary means of ventilation, a space of at least 1000 cubic feet should be allowed per head in buildings permanently occupied.

It may be objected that these conditions aim at too high a standard, and that in general they are seldom met with; but it must be remembered, as Dr. de Chaumont has so well pointed out, that they are based on a firm foundation of facts, and that though it may not be possible to prove in all cases that bad effects result from a neglect of them, it does not follow that such bad effects may not have been produced. In a country like this, with a climate so variable, the cubic space allowance is a most important element in any scheme of ventilation. It should be ample enough to permit of a sufficient supply of fresh air without creating injurious draughts, and yet not too large to interfere with the maintenance of a sufficient and equable temperature during cold weather. Where artificial ventilation is provided, and when the fresh air can be heated before entering, it may be as low as 400 cubic feet, but even then the ventilating arrangements must be much more perfect than they usually are. In the case of healthy adults, such as soldiers and prisoners, the standard allowance may also be considerably lessened, if care be

taken that the free entrance of fresh air at all hours and in sufficient quantity shall not be interfered with. Unfortunately the question of cubic space is a question of large outlay, and hence the desire to economise tends to curtail the minimum not within safe limits, but within limits that will not be attended with glaring injurious effects.

In advocating these conditions, however, it is but right to state that the numerous experiments and weighty opinions of Dr. Angus Smith are somewhat at variance with them. In the first place, Dr. Smith's experiments only gave ·4 cubic feet of carbonic acid per hour, which would reduce the requisite amount of fresh air supply per hour to 2000 cubic feet; and in the second place, Dr. Smith maintains that uniform diffusion of the contained air is the exception and not the rule, and in fact that it does not occur at all. With regard to the first of these points, the discrepancy between Dr. Smith's results and those of other physiologists may be reconciled on the ground that his trials were admittedly not made on large men; but with regard to the second, there still exists considerable divergence of opinion. If by uniform diffusion throughout an occupied space is meant the *exact* uniformity of the chemical composition of the air in every part, then it must be conceded that Dr. Smith is strictly correct; for so long as fresh air is entering and foul air issuing from a room, there will not only be a difference between the composition of the air in the immediate proximity of the inlets and outlets, but there will also be a difference in various parts caused by the currents, however imperceptible these may be. In small occupied spaces, such as prison cells, provided with adequate means for

artificial ventilation, the amount of fresh air required to keep the carbonic acid from exceeding ·6 per 1000 volumes must obviously be much less than the amount required per head in a large room, because uniform diffusion is impossible, there being a constant movement of the air from inlet towards outlet. But in a large space the case is different, even though the cubic space per head be not greater than that of the prison cell. The entering currents and the currents produced by inequalities of temperature are, in this instance, much more numerous, and produce a much greater mixing of the air, while the impurities given of by respiration have greater scope to be affected by the laws of gaseous diffusion. For all practical purposes, therefore, the condition of uniform diffusion as applying to a room occupied by several persons, may be accepted as sufficiently accurate; and this being so, the standard amount of fresh air to be delivered per head per hour must, as already stated, be 3000 cubic feet. Indeed, the whole of the controversy between Dr. Angus Smith, on the one hand, and Drs. Parkes and de Chaumont, on the other, regarding this point, seems to be based on a misunderstanding; each party estimates the requirements of ventilation for a single individual, but under different conditions—the former taking it for granted that the space is occupied by one, the latter that it is occupied by several.

Section III.—Natural Ventilation.

Natural ventilation is carried on by the agency of natural forces, such as gaseous diffusion and movements of air produced by inequalities of temperature.

1. *Diffusion.*—The force of gaseous diffusion, upon

which the uniform constitution of the atmosphere itself depends, is manifestly inadequate as a ventilating power. It operates chiefly in producing, as has been already stated, a tolerably equal distribution of the gaseous products of respiration and combustion throughout the air contained in a room, but aids only to a very slight extent the removal of these impurities from the room, while it is altogether inoperative as regards the removal of organic impurities.

2. *Movements of Air produced by Inequalities of Temperature.*—As common air is subject, like other gases, to the laws of gaseous expansion, it undergoes a certain increase or diminution in bulk, according as it is heated or cooled. Warm air is, therefore, lighter than cold air, and hence a constant interchange goes on through every available opening, whenever there is any difference between the outside and inside temperature. The contained air, on being heated, expands, a portion of it escapes, and the colder outside air rushes in to establish the equilibrium. In this way a constant stream of fresh air may be made to enter a room by simply keeping the inside temperature higher than the outside. But in addition to the slighter currents, the movements of the external air, or winds, greatly assist ventilation by their perflating or aspirating action. Perflation is best exemplified in the cross-ventilation which takes place through opposite windows when opened. This is by far the readiest means which can be adopted for removing speedily and effectually aerial impurities from a room, but it cannot always be depended on, on account of the uncertainty of the rate of movement; for if the air be stagnant, there can be little or no perflation, while on the other hand, if the

rapidity of movement is great, perflation becomes insupportable in consequence of the draughts produced. A current of cold air moving at the rate of five or six feet per second becomes unbearable. In spite of this objection, however, cross-ventilation should always be provided for whenever it is practicable, and especially in large rooms, such as hospital wards.

The aspirating action of the wind produces up-currents through chimneys and air-shafts, by creating a partial vacuum in them, which is constantly being filled by the column of air from beneath. The mechanical arrangements which have been proposed or adopted to facilitate the action of these natural ventilating powers are so numerous and varied, that only a brief mention of the more important of them can be given. To utilise the perflating force of the wind, opposite windows should be made to open from the top and bottom, and to obviate the unpleasantness arising from draughts, some such arrangements as the following have been recommended :—

(1.) By having the window so constructed that the top slopes inward when it is opened, so that the entering current of air impinges against the ceiling. If the window is large, as in churches or schools, only a section of the upper part may be made to open in this way.

(2.) By substituting a glass louvre for the top centre pane.

(3.) By having some of the panes doubled ; the outer with an open space at the lower edges ; the inner with an open space of the same size at their upper edges. The air on entering is thus made to pass upwards between the panes.

(4.) By fixing a fine wire screen to the top of the window, which unfolds when the window is pulled down, and folds up when the window is shut. As the fine meshes of the screen are apt to become clogged up with dust, this plan is objectionable, except when the windows are of low elevation, as in attic rooms.

Other outlets and inlets may be provided by inserting perforated bricks in the walls near the ceiling. One of the best inlets is the Sheringham valve, which closes at will by a balanced weight. It slopes inwards and upwards when open, so that the entering current of air, which first passes through a perforated brick or grating, is directed towards the ceiling.

In some cases cross-ventilation can be tolerably well maintained, independently of opposite windows, by means of transverse ventilating boxes or tubes, situated at regular distances, and in close proximity to the ceiling. These boxes or tubes extend from wall to wall, and communicate with the external air at either end by air-bricks. The sides are made of perforated zinc, and there is a diaphragm in the centre of each, to prevent the wind from blowing right through. According to the direction of the wind, one-half the tube becomes an inlet for fresh air, which falls gently into the room through the perforated zinc, while the other half becomes an outlet for the vitiated air.

This plan does very well for large hospital wards having an internal corridor running along one side. Inner rooms can also be supplied with a certain amount of cross-ventilation in the same way.

The aspirating power of the wind is best utilised by placing cowls on the tops of air-flues or chimneys. They should be made to rotate according to the direc-

tion of the wind by means of vanes, and in order to prevent the entrance of rain, their upper margin should always project to some extent. A very good form of cowl, and more suitable for large air-shafts, consists of a movable cylinder, shaped somewhat like a French *kepi*, with an opening in front, and surmounted by a vane, so that the front is always turned away from the wind. All cowls have to be well balanced, and so adjusted that they can rotate readily, without becoming fixed.

Louvres are sometimes used instead of cowls, but unless specially constructed, they are apt to let in the rain, and permit down-draughts. Mr. Ritchie has endeavoured to obviate these defects by providing a movable cylinder, turning with a vane inside the louvre, and with an opening in the side turned away from the wind, through which the air passes. It will be observed that this arrangement merely places the cowl inside the louvre, and that, apart from architectural appearance, it does not possess the advantages of the cowl itself.

In several plans of natural ventilation the perflating and aspirating powers of the wind are both taken advantage of. Thus, in Mr. Sylvester's plan, which was in use fifty years ago, a large cowl surmounted the fresh air entrance shaft, and by means of a vane was always made to face the wind. The shaft itself was erected at a convenient distance from the building to be ventilated, and of a height varying according to circumstances. In this way the air, so to speak, was blown into the cowl and down the entrance-shaft into a chamber beneath the basement floor, where it could be heated if necessary. It then ascended by tubes leading to the

different parts of the building, and finally passed out through a shaft or shafts projecting above the roof, and also fitted with cowls turning away from the wind, so as to act as aspirators.

By a suitable arrangement of shafts and cowls, this mode of natural ventilation can be made to do excellent service in ships and in buildings so constructed or situated that other ventilating means will not suffice. It was on this principle that Dr. Arnott ventilated the Field Lane Ragged School so successfully. The entrance and exit tubes were both fitted with cowls, the one set turning away from the wind, the other facing the wind. The latter also were of a higher elevation than the former, in order to increase their extractive power.

A system of natural ventilation well suited for large rooms, and which has been highly spoken of by Mr. Robson, architect to the London School Board, is that devised by Mr. Potts. It consists of a hollow metal cornice running continuously round the room, and divided longitudinally throughout its whole length into two separate channels by a plate attached to the lower one. The fresh air is admitted through openings in the wall into the lower channel, and falls imperceptibly into the room through numerous perforations. The upper channel communicates either with the smoke-flue or other air-shaft, and receives the vitiated air through a series of small openings similar to those of the lower channel. As the fresh air being colder descends by its own gravity, and the vitiated air being warmer, rises to the highest point, there is no doubt that the principles of the system are correct. Mr. Robson strongly recommends it for facility of application to buildings origin-

ally erected without proper provision for ventilation, for sightliness, economy of first cost, and self-acting properties.

Another plan, which has been found to work well in schools, has been proposed by Mr. H. Varley. A perforated zinc tube communicating with the external air passes round the cornice of three sides of the room, while on the fourth side another perforated tube is connected with the chimney, which acts as the extraction-shaft.

The plan proposed by Mr. M'Kinnell, though it belongs to the same category, is less widely applicable than either of these two, because it is only suited for one-storied buildings or upper rooms. It consists of two hollow cylinders, one within the other, and of such relative calibre that the transverse area between the tubes is equal to the sectional area of the inner tube. The inner tube is of slightly higher elevation than the outer, and acts as the outlet. The fresh air enters between the tubes, and is thrown up towards the ceiling by means of a horizontal flange surrounding the lower margin of the inner tube. Both tubes should be situated in the centre of the ceiling or roof.

For ventilating workshops or factories, a plan has been advocated by Dr. Stallard, which appears to possess some special merits beyond those of mere novelty. He proposes that the ceiling of every workshop should be formed of zinc or oiled paper pierced by numerous small holes. Above this perforated ceiling, and between it and the roof, or between it and the next floor above, there should be a free space or air-chamber open to the atmosphere on all sides. This plan, while it would not interfere with ventilation by open windows nor with

ordinary methods of warming, would give free play to the different modes of natural ventilation, and is intended to supply, as nearly as possible, the conditions of living in the open air, summer and winter, without exposure to extremes of weather.

Section IV.—Artificial Ventilation and Warming.

It will be convenient to consider these two subjects conjointly.

Artificial ventilation is carried on either by forcing the air into, and through, a room (propulsion), or by drawing the air out of a room (extraction). These two methods are also spoken of as the *plenum* and *vacuum* systems of ventilation.

Although it may appear to be an easy matter to ventilate a room without any regard to temperature, or to warm it without providing for a due supply of fresh air, it becomes a problem of very considerable difficulty to ensure in all cases that both the ventilation and warming shall be efficient and satisfactory. This difficulty depends in a great measure on the fact that the means employed in ventilating necessarily dissipate and carry off a certain quantity of the heat which should be utilised for warming purposes.

In this country artificial ventilation and warming are usually provided for by open fire-places. The heat is obtained by radiation from the incandescent fire, and by radiation and reflection from the different parts of the grate, while ventilation is carried on by the constant current of heated air rushing up the chimney. Even when there is no fire, the chimney acts as a very efficient ventilating shaft.

When doors and windows are closed and a fire kept burning, the fresh air enters the room through every chink and opening, provided there are no special inlets. Hence it follows that the more closely doors and windows are made to fit, so much greater are the obstacles to the entrance of fresh air. When this is the case, the fire feeds itself by establishing a double current in the chimney, the downward current entering the room in puffs, and carrying with it clouds of smoke. Generally, however, doors and windows are not made to fit so closely that a sufficient amount of air for feeding the fire cannot enter, and under ordinary circumstances the supply and circulation are somewhat as follows :—The greater portion of the fresh air enters beneath the door, and is drawn along the floor towards the fire-place. It is warmed to a certain extent during its course by the radiating heat of the fire, and when it approaches the fire-place, part of it rushes up the chimney along with the smoke, while the other part ascends towards the ceiling, and after ascending passes along the ceiling towards the opposite end of the room. During its progress it becomes cooled, and therefore descends to be again drawn towards the fire-place with a fresh supply from beneath the door and through the chinks of the window-frames, if they are not air-tight. As the air which thus enters is usually cold air, it is evident that the room is insufficiently or unequally warmed and badly ventilated. At the end of the room opposite the fire-place the temperature is below the average, and the cold current near the floor chills the feet. Moreover, the air is not properly diffused, so that although a sufficient supply may actually be entering, impurities are apt to accumulate in the centre and upper parts of the room.

With ordinary fire-places, it is found that nearly seven-eighths of the heat generated passes up the chimney, along with a quantity of air varying from 6000 to 20,000 cubic feet per hour. While, therefore, a single chimney will on the average act as an efficient ventilating shaft for a room containing from three to six or more persons, it is quite clear that by far the greatest portion

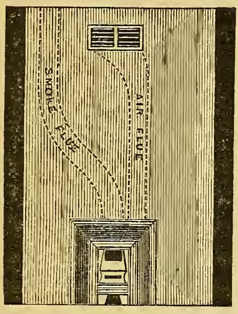


Fig. 1.—Elevation, showing air and smoke flues.

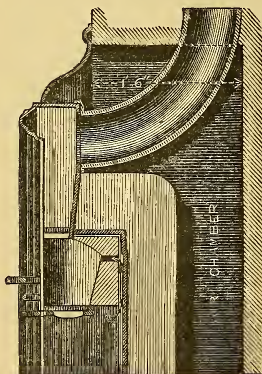


Fig. 2.—Section of grate.

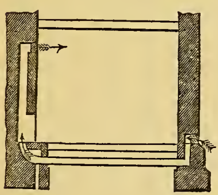


Fig. 3.—Section of a room showing air-duct and flues.

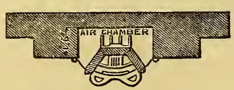


Fig. 4.—Plan of grate and air-chamber.

(After Galton.)

of the fuel is wasted as a warming agent. The structure of the fire-place thus becomes a matter of special importance, because not only may the fuel be economised to a considerable extent, but by certain mechani-

cal arrangements an equable temperature may be maintained, and the air warmed before it enters the room.

Of the fire-places adapted to meet these requirements, one of the best is the stove devised by Captain Douglas Galton (see figs. 1, 2, 3, and 4). It provides for an air-chamber at the back, in which the fresh air is heated before it enters the room. If the fire-place be built in an external wall, the inlet for fresh air may be situated immediately behind, but if in an inner wall, a channel communicating with the external air by perforated bricks or gratings, and passing beneath the flooring or behind the skirting, must be laid. On the back of the stove broad iron flanges are cast, so as to present as large a heating surface as possible. These project backwards into the chambers, and this heating surface is further supplemented by the smoke-flue, also of iron, which passes through the chamber, and is made continuous with the chimney. The fresh air heated in this manner enters the room by a louvred opening situated between the fire-place and ceiling, or by two such openings, one at either side of the chimney-breast. The grate itself is so constructed that the greatest amount of obtainable reflected heat is given off, and a more perfect combustion of the smoke effected than with an ordinary grate. The stoves are of different designs and sizes, to suit existing chimney-openings and different-sized rooms. They have the same cheerful aspect as the ordinary grate, and produce the same degree of warmth in a room, with a third of the quantity of fuel; besides, the temperature of the room is much more equable, and unpleasant draughts of cold air are avoided. Kitchen stoves have also been constructed on the same principle, and stoves suited for the centre of halls or

wards. The smoke-flue of the latter is made to pass out under the flooring, and inside the fresh-air entrance channel, thus supplying a larger heating area for the entering air. The terra-cotta stoves in Herbert Hospital are of this description.

A very cheap and improved fresh-air cottage grate has been devised by Mr. Penfold of London. It is composed of well-burnt fire-clay, with a chamber at the back, as in Galton's stove, in which the fresh air can be heated and discharged into adjoining rooms. This plan of supplying adjoining rooms with heated air was first introduced by Cardinal Polignac in 1713.

In order to secure the combustion of the smoke, several grates have been invented. One of the most recent, and which has been well spoken of, is that patented by Messrs. Young Brothers of Cheapside. The coals are introduced into a trough fixed to the lower portion of the front of the grate, then, by means of a right and left handed screw worked by a ratchet-wheel, the burning fuel is raised, and the contents of the trough emptied into the cavity.

Of the numerous stoves intended to economise fuel, it will be sufficient to notice only a few of those which have been found to work more or less successfully as ventilating stoves.

1. *The Goldsworthy-Gurney Stove.*—This consists of a plain iron cylinder, surrounded by a series of upright gills or flanges, and placed in a water pan, in order that the heat rendered latent by evaporation may be carried to the distant parts of the room in the moistened currents of air which proceed in all directions from the stove. The fresh air enters through a channel opening beneath the stove, and is heated by the warm flanges

surrounding it. As the water in the pan is steadily evaporated by the heat of the stove, the air in the room never becomes burnt or over-dried.

2. *Musgrave's Slow Combustion Stove.*—This resembles the Gurney stove in being surrounded by rows of flanges or ribs, but is more complicated in its internal arrangements. The receptacle for the fuel is lined with fire-clay blocks, and is large enough to contain the fuel necessary for twenty-four hours' consumption. As the fire is lighted from beneath, and the stove is charged through a sliding-door at the top, the fire may be kept burning for a whole year without requiring re-lighting, provided it be regularly fed and the ashes not allowed to accumulate. Before escaping through the smoke-flue, the smoke and other products of combustion are forced through two auxiliary spaces in the stove, and impart almost the whole of their heat to the stove with its appendages during their passage. The fresh air to be heated is supplied by a special channel.

3. *Pierce's Pyro-pneumatic Stove-Grate.*—In this stove the fuel is burned in an open grate, surrounded by fire-lumps, which impart their heat to the fresh air entering beneath.

4. *The Calorigen Stove,* lately invented by Mr. George, is adapted for burning gas, or as an open fire-place. The body of the stove is made of thin rolled iron, and contains a coil of wrought-iron tubing, which is open at the top of the stove, and communicates with the external air beneath. The fresh air is warmed during its passage through the coil, and enters the room at a moderate temperature. Connected with the gas stove is a cylinder placed outside the wall, and furnished with two pipes which communicate with the interior of

the stove. This cylinder is open at the top, and admits the air necessary for the combustion of the gas, which is warmed to a certain extent by the products of combustion passing along the upper horizontal tube and issuing through the same opening (see fig. 5). Waste of heat is thus prevented, and any communication between the furnace of the stove and the air of the room is avoided. In the other stove the air of the room supplies the fire (see fig. 6). According to Mr. Eassie, C. E., 14 lbs. of coal burned in this stove will suffice to heat a room of 15 feet square for 16 hours. There is no doubt, therefore, that the Calorigen is economical, and as it affords equable warmth with good ventilation, it has been highly commended.

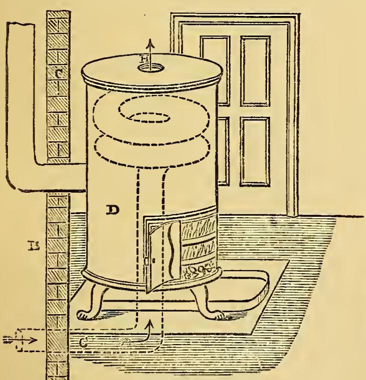


Fig. 6.

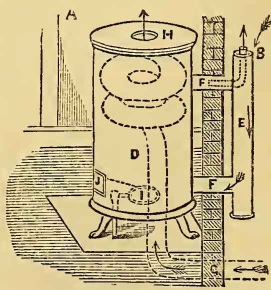


Fig. 5.

A—the interior of the Room ; B—exterior of the Building ; C—Wall ; D—the Calorigen ; E—a Cylinder ; F—Pipes communicating to supply air for combustion, and carry off product ; G—Pipe for passage of Cold Air to Calorigen ; H—outlet for ditto after being made warm ; I—Gas-burner ; J—Door.

The great objection to many of the commoner kinds of stoves depends on the fact that their over-heated surfaces dry the air to a very unwholesome extent, even

when the fresh air is conveyed by a special entrance channel. Numbers of them, however, are put up without providing any such channel, so that the air not only becomes dry and burnt, but exceedingly close and unpleasant. Evaporating dishes placed on the stoves will assist in remedying this evil, but it is much preferable, and in the long run more economical, to have a good ventilating stove erected in the first instance.

For all ventilating stoves it is necessary that the fresh-air channels should be removed from all sources of contamination, such as drains, closets, stables, etc. And it is advisable to protect the external openings by perforated bricks or gratings. The size of the stove, and the sectional area of the air-channel, must of course be regulated by the size of the space which is to be warmed and ventilated.

Stove smoke-flues may be either ascending or descending, but in the latter case a pilot-stove or rarifier ought to be fixed at the base of the upright chimney which receives the flue, otherwise the draught may prove faulty. Soot doors should be provided at all the bends, wherever practicable.

With the ordinary grate, the ventilation of a room may be very greatly improved by providing an entrance into the chimney near the ceiling, and to prevent reflux of smoke, the opening should be valved, as in Dr. Arnott's chimney ventilator. One or more openings for the entrance of fresh air could be obtained by inserting perforated bricks or Sheringham valves in the outer walls, also near the ceiling, but at a distance from the fireplace.

Instead of an opening leading directly into the chimney for an outlet, a much better plan is to have a flue

running alongside the chimney, the entrance to the flue being situated near the ceiling. The hot air in the chimney warms the flue, and there is thus a constant upward current established without any risk of reflux of smoke. But this is an arrangement which can only be attended to in the original plan of a building; it cannot be applied as an improvement afterwards.

Some architects recommend that all the rooms in a well-constructed house should be supplied with warm air from the hall and staircase. In Mr. Ritchie's plan the air is heated to about 70° Fahr., and enters the various rooms through longitudinal openings over each door. After being diffused through the rooms it then passes up the chimneys and through flues reaching from the ceiling to the wall-heads under the roof.

Large and compact buildings, such as hospitals, asylums, and prisons, can be very efficiently warmed and ventilated by a suitable arrangement of hot-water pipes. The fresh air, as it enters through openings properly distributed throughout the building, is warmed by passing over the pipes, while the vitiated air may be extracted by means of other coils of heated pipes situated in extraction-shafts.

Another mode of ventilation by extraction, and one which is frequently used in prisons, consists in having a large foul-air extraction-shaft or shafts, heated by a furnace at the bottom, and into which foul-air flues, leading from all parts of the building, are conducted. The workmanship in this case requires to be very perfect, so as to prevent any large currents of air reaching the shaft except through the flues.

By a combination of these two methods, viz.—heating the fresh air before entering by hot-water pipes,

and securing the removal of the vitiated air by flues leading to furnace-shafts, the largest buildings can be well warmed and ventilated. If necessary, the hot-water pipes may be made to pass through shallow basins of water, to ensure a sufficiency of moisture in the contained air.

Almost all large mines are ventilated on this principle of extraction. By means of a furnace at the bottom of the upshaft, the air is drawn down another shaft and made to traverse the various galleries by an arrangement of partitions and double doors. In well-ventilated mines as much as 2000 cubic feet of air per head per hour can be supplied in this way, and in fire-damp mines, 6000.

In men-of-war, an iron casing surrounding the bottom of the funnel and upper part of the boilers is utilised as an extraction-shaft. When the fires are kept burning, so great is the current which rushes up this shaft, that the air can be drawn through the hatchways from all parts of the vessel, and even the hold and timbers ventilated.

In theatres, and other buildings of a similar description, the chandeliers should always be employed to extract the vitiated air. According to the experiments of General Morin, one cubic foot of gas can be utilised so as to cause the discharge of 1000 cubic feet of air. Apart, therefore, from the great advantages arising from the direct removal of the products of combustion, the aid to ventilation furnished by the extractive power of gas-lights merits special attention, for, as a common gas burner will burn nearly 3 feet of gas per hour, its extractive power could thus be utilised to remove nearly 3000 cubic feet of vitiated air during the same period.

Where a large flood of light is required, the "sun-burner" acts very efficiently in this way, and for smaller rooms or workshops, the "box-top sun-burner" is found to answer very well. Rickett's new "ventilating globe-light" ought also to be mentioned amongst the latest improvements in this direction. It is so arranged that so soon as the gas is lighted, an upward current is produced in the main tube, and as this becomes heated, the air in the surrounding tube near the ceiling becomes rarefied and set in motion. In this way the heated air in both tubes is carried to a special shaft or to the chimney, thereby securing the removal of the products of combustion, and a steady current outwards of the vitiated air in the room. Tubes of tin or zinc placed over common burners, and communicating with the external air, or leading into the chimney, would answer the same purpose, where ornamentation can be dispensed with. Indeed, the principles of ventilation by gas-lights are in general so easy of application, and the advantages to be gained are so manifest as regards health, that it is surprising they should still be so greatly neglected.

Extraction by means of a steam jet, and extraction by a fan or screw, are now generally abandoned on the large scale. What is known as the Archimedean-screw ventilator, however, has been lately recommended for small air-shafts, and has also been applied to large factories, where it may be worked by hand or steam power. In mines, the fan has been made to extract as much as 45,000 cubic feet of air per minute.

The system of ventilation by propulsion was first introduced by Dr. Desaguliers in 1734. It is carried on by means of a fan inclosed in a box, which can be worked by hand, horse, water, or steam power. The

air enters through an opening in the centre of the box, and is thrown by the revolving fan into a conduit which communicates by proper channels with the different parts of the building. In France and America the fan is employed in the ventilation of several of the large hospitals, the air being forced into a basement chamber where it is heated before it enters the wards. This is known as Van Hecke's system. In this country St. George's Hall, Liverpool, may be cited as affording an example of ventilation by propulsion on the large scale. The air is taken from the basement, and washed by being passed through a thin film of water thrown up by a fountain. It is then passed in cold weather into vessels for the purpose of being warmed, and in which it can be moistened by a steam jet whenever the difference between the dry and wet bulb exceeds 5°, and finally, it is propelled along different channels into the hall. In summer, the air in the conduits is cooled by the evaporation of water.

Various other methods of propulsion have been tried such as the bellows' arrangement proposed by Dr. Hales, or the gasometer pump worked by hydraulic pressure planned by Dr. Arnott, but mostly all of them have fallen into disuse.

Concerning the relative merits of these two systems of ventilation, viz. extraction and propulsion, the balance of evidence is most decidedly in favour of the former, as regards cost, efficiency, and stability. In either system, natural ventilation plays a most important part, whether it be taken into consideration in the construction of buildings or not; and hence every facility should be afforded for its operation, without at the same time permitting its disadvantages to take effect. For dwell-

ing-houses, workhouses, asylums, barracks, and hospitals, there is no doubt that natural ventilation, aided by the extractive power of the heat generated in warming and lighting, is by far the best system. On the other hand, buildings such as prisons, theatres, etc., must be ventilated by mechanical appliances, and experience has proved that these should provide for ventilation by extraction.

General considerations.—With regard to the relative position of inlets and outlets, there seems to be some difference of opinion. Theoretically, the inlets for the fresh air should be situated near the floor, and the outlets near the ceiling; but the question of temperature interferes with the practical application of this rule. If the air is not warmed before entering, the inlets should be at least 9 or 10 feet from the floor, or close to the ceiling, and so constructed that the cold air will impinge against the roof, and fall gently into the room. They should slope upwards to prevent entrance of rain, and should communicate with the external air by means of perforated bricks or gratings, so as to divide the entering current and break its force. Valves or circular rotatory discs should also be provided, in order that they may be partially or totally closed during rough weather. If the air is warmed before entering, the inlets may be situated, and generally are situated, near the level of the floor. But in either case it is essential that they should be equally distributed throughout the room, to ensure proper diffusion, and that the structural arrangements should permit of their being readily cleaned out, because dirt is sure to accumulate.

The outlets, as already stated, are best situated near the ceiling, not only because air vitiated by respiration

tends to ascend on account of its lessened density, but because experiment proves that, given the same extractive power and the same size of outlet, a greater volume of air passes up a flue whose orifice is near the ceiling than up one whose orifice is near the floor. Inlets and outlets should not be situated near each other, otherwise the entering air will be extracted without being first diffused throughout the room.

Outlet tubes, or foul-air flues, as they are generally called, should be smooth, so as not to impede the current of air by friction, and in systems of ventilation by extraction, they should be air-tight. When built in external walls and only plastered, I have frequently satisfied myself by experiment that the outside air finds its way into the flue, and sometimes in such volume that though there may be a good current issuing from the top, scarcely any current can be detected entering it at the bottom. I have also found that when the wind beats strongly against the side of a building, with foul-air flues situated in the outer walls, a current of air may actually be issuing from both orifices at the same time. The experiments of Pettenkofer explain how readily such an occurrence may take place, for he has proved beyond doubt that even under ordinary atmospheric conditions, a very considerable interchange of gases takes place through common dry-plastered walls, and indeed, as the sick often experience, very perceptible draughts find their way through outer walls when a stiff breeze is blowing. All foul-air flues, therefore, should be as nearly air-tight as possible, and if they were made of metal tubing or of glazed earthenware, they would not only satisfy this condition, but would serve greatly to lessen the friction which is such an impediment to

ready extraction through common plastered flues. It is further evident that, when it can be avoided, they should not be situated in external walls, because in cold weather the air becomes cooled as it ascends, and unless the extractive power is very considerable, the increased weight of the column of air by loss of heat will counteract the extractive force. Where there is no system of artificial extraction, it thus often happens that outlets become inlets, and inlets outlets.

Another very important point remains to be considered, namely, the sectional area of the inlets and outlets. As atmospheric conditions are constantly varying, it is obviously impossible to fix upon any size which will meet every requirement. The only alternative therefore, is to provide an area that will suit the majority of cases, and which will be capable of being increased or diminished according to circumstances. Dr. Parkes has pointed out that in this country a size of 24 square inches for inlet per head, and the same for outlet, is the one best adapted to meet common conditions. Theoretically, the sectional area of the outlets should vary according to the height of the foul-air flues, and the Barrack Commissioners have accordingly recommended that it should amount to 1 square inch for every 50 cubic feet of space for upper floors, to 1 square inch for every 55 cubic feet for rooms below, and to 1 square inch for every 60 cubic feet for rooms on the ground-floor, in buildings of three stories. Practically, however, these nice distinctions may be disregarded, because the friction in long flues lessens very considerably the advantage in extractive power attaching to them, on account of their greater height, and also because, in the great majority of cases, the column of air in the flue increases

in density the higher the flue. In prisons where the cubic space per head is comparatively small, the sectional area of inlets and outlets should be at least 20 square inches per head. In barracks, hospitals, etc., the separate inlets should not exceed 1 square foot, otherwise the entering air will be badly distributed.

More precise details with regard to the ventilation of hospitals will be given in the chapter on hospitals.

CHAPTER V.

EXAMINATION OF AIR AND VENTILATION.

A DETAILED examination of the sufficiency of ventilation in any particular case will embrace the following inquiries :—

1. The arrangements as regards cubic space, the relative size and position of inlets and outlets, the distribution of the air, and the amount of fresh air supplied.

2. The examination of the contained air by the senses.

3. Chemical examination of the contained air.

4. Microscopical examination of suspended impurities.

5. Examination as regards temperature, moisture, etc.

SECTION 1.—EXAMINATION AS REGARDS VENTILATING ARRANGEMENTS.

The measurement of the cubic space is a simple question of mensuration, but corrections must be made for furniture, bedding, etc., and for inequalities in the contour of the space to be examined. For instance, the displacement caused by solid projections into the room must be deducted, and the cubic contents of open recesses added. The allowance for each bedstead and

bedding may be estimated at 10 cubic feet, and for the space occupied by the body of each person at 3 cubic feet.

After the exact cubic space per head has been ascertained, the next points to be inquired into are the relative position and size of inlets and outlets. Perforated bricks and gratings can be approximately estimated, as regards their total open sectional area, by taking their actual superficial area, and calculating the relative size of the interstices. Inlets should be inspected as regards their freedom from accumulation of dust, etc., and outlets as regards the presence of any impediments to the ready exit of the vitiated air. Where there are open fire-places the sectional area of the smoke-flue must also be ascertained. The existence or otherwise of unpleasant draughts, and the relative position of doors and windows, and how far they assist in the ventilation of the room, are other items which must not escape notice. If the system of ventilation is artificial, it should be examined in all its details, and in this examination great assistance will be derived from inspecting the architect's plans, whenever they can be procured.

The directions of air-currents in a room can be ascertained by means of the smoke from smouldering cotton, velvet, fibres of floss-silk, small pieces of feather, small balloons filled with hydrogen gas, etc. The flame of a candle is often used for the same purpose, but it is of no value when the currents are delicate, because it is unaffected by them, but is of considerable service in showing whether air is entering or issuing through any opening. Very frequently, as has already been pointed out, openings that are meant to be inlets act as outlets,

and *vice versa*, or the movement of air in them may be unstable, intermittent, and reversed in its action, now entering and now issuing through the same opening.

All these points, and others which may arise from peculiarities of structural arrangement, must be carefully inquired into, and the various measurements and observations noted down as they are made. When the ventilation is intended to be carried on independently of open doors and windows, these should be closed during the examination.

In determining the rate of movement through the various openings, an instrument called an anemometer is generally used. This may briefly be described as a miniature windmill. The little sails, driven by the air-current, set in motion a series of small cogged wheels, which move an index or indices on a dial-plate. The velocity of the current can thus be read off for a given time, in the same way as the amount of gas which has been consumed is ascertained from a gas-meter.

At the suggestion of Dr. Parkes, a very beautiful and delicate instrument of this description has been constructed by Mr. Casella, of Hatton Garden, with indices on the dial-plate indicating the velocity of an air-current in feet, hundreds of feet, thousands, etc., up to millions. By moving a catch, the machinery may be stopped at any moment of time. With this instrument, the rate of movement of air through any opening is readily, and, as a rule, accurately ascertained. Before using it, the index indicating feet in units should be set at zero, and the relative position of as many of the other indices as may be deemed necessary noted down. When the instrument is placed in the air-current, time is called, and the catch moved to set the machinery free. At

the end of one minute, two minutes, etc., according to the length of period of observation, time is again called, and the machinery immediately stopped by means of the catch. The linear dimension of the current is then read off, and if this is multiplied by the sectional area of the opening, the volume of air which has passed through in a given time can be easily calculated in cubic feet. When the instrument is placed in a tube or shaft, it should be put well in, but not quite in the centre, because the velocity of the current in the centre is greater than at the sides of the tube. Should the shaft be large, the rate of movement ought to be taken at different parts, and the average ascertained. So also, when the rate of movement is irregular, several observations should be made, and the average of the whole of them will give the approximate velocity of the current. If placed in a tube whose sectional area exceeds but very little the space occupied by the revolving sails, the results cannot be depended on; and when placed at the entrance of a tube, for example, against a perforated air-brick or grating, the velocity of the current indicated by the anemometer is considerably less than what exists in the tube.

The amount of air found to be issuing up chimneys or other outlets is a far more reliable index of the fresh-air supply than the amount actually ascertained to be entering through the inlets; and indeed the fresh-air supply can only be fairly estimated in this way. As already stated, the air enters through every chink and cranny, and in dry plastered walls may enter, to no slight extent, through the walls themselves. Hence the difference between the amount of air found to be entering through the regular fresh-air inlets, and that found

to be issuing through the outlets, is often very great. In a ward containing 15 beds, with one door, eight windows, and four inlets for fresh air, I have found that while only 880 cubic feet of fresh air were entering through the inlets per bed per hour, as much as 3150 were found to be issuing up the two chimneys and the three extraction-flues of the ward. During the experiments the door and windows were shut, and brisk fires kept burning in the two ventilating fire-places. The large amount, therefore, of 2270 cubic feet per bed per hour entered through chinks in the window-frames, and beneath and around the closed door. Very probably in this instance a considerable amount was also drawn, by the extractive force of the chimneys and flues, through the walls, inasmuch as they were built of brick, and were only whitewashed and not plastered.

When an examination of the respired air itself is intended, a suitable time must be selected, during which all the conditions of the efficiency of the ventilation, in any given instance, can be fairly put to the test. Take an hospital ward, for example. It is necessary that all the beds should be occupied, that windows and doors be kept shut, if ventilation is intended to be effectually carried on without them, and that an hour should be selected in the night-time when the greatest accumulation of impurities is likely to occur. Any hour between midnight and 5 A.M. would meet this condition in most cases. In order to make the examination as complete in detail as possible, it is necessary to have a wet and dry bulb thermometer placed outside some time previously, and several others fixed at different positions in the ward. The outside and inside temperature can thus be compared, and the relative hygrometricity of

the air indoors and outdoors ascertained. If the barometer is read off at the same time, and the state of the weather recorded, all the meteorological data are obtained which are usually considered necessary for a full and exhaustive report.

Section II.—The Examination of the Contained Air by the Senses.

With a little practice, this method of examination gives tolerably reliable results; but it is necessary that one should remain for some short time in the open air, before entering the ward or room to be examined, otherwise the sense of smell is likely to be blunted and unable to appreciate the degree of closeness or foulness. One of the terms, "not close," "rather close," "close," "very close," "foul," "very foul and offensive," will indicate, with sufficient accuracy, the degree of perceptible impurity in the majority of cases. The following selections from Dr. de Chaumont's experiments show how closely the sensations accord with the different degrees of impurity indicated by the percentage of carbonic acid.

At ·1408 per cent.	Extremely close and unpleasant.	At ·0843 per cent.	Not very foul.
„ ·1090 „	Extremely close.	„ ·0804 „	Close.
„ ·0962 „	Very close.	„ ·0658 „	Not very close.
„ ·0921 „	Close.	„ ·0568 „	Not close.

Section III.—Chemical Examination.

1. *Carbonic Acid.*—In the chemical examination of respired air, the chief point to be determined is, the amount of carbonic acid per 1000 volumes. Pettenkofer's method is the one most generally adopted, because

it is alike accurate and easy of application. For the analysis, which is volumetric, French weights and measures are used. The following apparatus and solutions are also required (see Appendix II.) :—

(1.) Two or more glass jars, each capable of holding 4000 to 6000 centimetre cubes, and fitted with india-rubber caps.

(2.) A Mohr's burette, graduated into centimetre cubes and tenths, fitted with pinch-cock, and large enough to hold 50 or 100 centimetre cubes.

(3.) A narrow glass measure, marked to measure 30 and 60 centimetre cubes exactly.

(4.) A pair of bellows or a bellows-pump.

(5.) Turmeric paper specially prepared. (Turmeric powder should be boiled in alcohol, and ordinary filtering paper steeped in it, then washed and dried.)

(6.) Pure clean lime water. (Both Dr. Angus Smith, and lately Pettenkofer, prefer baryta water, but I follow in my description the plan pursued by Drs. Parkes and de Chaumont, according to which my own analyses have been made.)

(7.) A solution of crystallised oxalic acid, 2·25 grammes to the litre of distilled water.

The capacity of the glass jars must be accurately determined by means of a litre measure graduated into centimetre cubes, and it is convenient to affix the cubic contents, expressed in centimetre cubes, to each. Before being used it is necessary that the jars should be perfectly clean and dry.

The analysis depends on the relative degree of causticity of the lime water before and after it has absorbed the carbonic acid contained in the sample of air to be examined. Thus 1 cubic centimetre of the above solu-

tion of oxalic acid exactly neutralises 1 millegramme (·001 gramme) of lime; and hence the amount of lime contained in a given quantity of lime water can be readily determined by adding the solution until the point of neutralisation is reached. The amount of oxalic acid solution required for neutralisation expresses the causticity of the lime water. If now the causticity of the lime water is known before and after it has absorbed the carbonic acid in the air contained in the glass jar, the difference will give the amount of lime in milligrammes which has united with the carbonic acid, and the amount of the latter is obtained by calculating according to the atomic weights.

The amount of neutralisation is determined by means of the turmeric paper. The test solution of oxalic acid should be run into the measured quantity of lime water from the burette, and the mixture constantly stirred with a glass rod. Every now and again a small drop of the mixture is conveyed on the tip of the rod to the turmeric paper, and one can readily judge by the tint of the stain when the point of neutralisation is approached. With pure lime water the stain produced is an intense dark brown, and as the oxalic acid solution is added, it becomes gradually paler on each application, until at last the centre of the stain is not tinted, and the margin alone appears as a delicate brown ring. The solution should now be carefully added drop by drop, and when the tint of the ring also disappears, the point of neutralisation has been reached.

In making a single analysis, it is advisable to use two jars, because otherwise a repetition of the experiment would not be possible were it required. Under ordinary circumstances, however, as many analyses can

be made as there are jars used for collecting samples of the air from different parts of the same room or building. The air to be examined is forced into the jars by means of a pair of bellows, and, by a suitable arrangement of tubing connected with the bellows, it can be pumped into them from any part of the room. In the case of small occupied spaces, such as prison-cells, when it is not desirable to disturb the ventilation by opening the door, the contained air can in this way be pumped into the jars through any opening, such as the inspection-hole in the door,—care being taken that the tubing and its connection with the bellows are perfectly air-tight, and that the bellows-valve acts efficiently.

Instead of bellows, a bellows-pump may be used, but in either case the nozzle should be long enough to reach the bottom of the jar. Dr. Angus Smith prefers using the bellows-pump, exhausting the air in the jar, and thus ensuring that its place shall be taken by the air to be examined. Pettenkofer and Dr. Parkes, on the other hand, pump the air into the jar; but either method answers very well, provided that care be taken that the jar is really filled with the air to be examined.

After the jar has been filled, 60 cubic centimetres of lime water are introduced, and the mouth of the jar closed by a tight-fitting india-rubber cap. If tubing has been used to convey the air from a distant part of the room, or from a small inhabited place without entering it, it is necessary that this part of the experiment should be performed rapidly, in order to prevent escape by diffusion, and therefore the measured quantity of lime water should be ready to be poured into the jar whenever the nozzle of the bellows is with-

drawn. The jar is then well shaken, so that the lime water is made to wash the contained air thoroughly, and afterwards is left to stand for a period of not less than six or eight hours, and not more than twenty-four. 60 cubic centimetres are introduced, in order that 30 may be taken out for analysis. So much of the lime water adheres to the sides of the jar, that the whole amount introduced cannot be poured out; and hence, if a repetition of the experiment is necessary, another jar must be used.

In making the analysis, 30 cubic centimetres of the lime water which has been employed are poured into a mixing jar, and its causticity determined as above described by the test solution. Then 30 cubic centimetres are taken from the jar, and the causticity also determined. The causticity of the lime water is found to vary from 34 to 41, according to its strength; in other words, from 34 to 41 cubic centimetres of the oxalic acid solution will be required for neutralisation, while the causticity of the lime water in the jar will be lessened in proportion to the amount of carbonic acid in the contained air. The difference between the first and second operations is doubled, to account for the 30 cubic centimetres left in the jar, and the product gives the amount of lime which has combined with the carbonic acid. The amount of the latter, as already observed, is obtained by converting weight into measure according to the atomic weights, and in one sum the factor is found to be ·39521. The capacity of the jar being known, and a deduction of 60 cubic centimetres made for the space occupied by the lime water, the amount of carbonic acid becomes a question of simple proportion. Thus, to take an example—Suppose the

causticity of 30 cubic centimetres of the lime water is 39·5, and the causticity of the lime water in the jar is 33·5; suppose also that the capacity of the jar is 5060 cubic centimetres; then, to find the ratio of carbonic acid per 1000 volumes, that is per 1000 cubic centimetres, the problem is as follows:—

$(5060 - 60) : 1000 :: [(39{\cdot}5 - 33{\cdot}5) \times 2 \times {\cdot}39521] : x$

therefore $x = \frac{6 \times {\cdot}79042}{5} = {\cdot}948$ carbonic acid per 1000 volumes.

It will thus be seen that the calculations may be simplified by adopting the following rule:—Multiply the difference between the causticity of the lime water, before and after it has been placed in the jar, by 790, and divide this sum by the number of centimetre cubes contained by the jar, *minus* 60. The result will be the ratio of carbonic acid per 1000 volumes.

But a certain correction must be made for temperature, according as it is above or below the standard of 62° Fahr. As the co-efficient of expansion of air is ·0020361 for every degree Fahr., the rule for correction may be stated with sufficient accuracy thus:—For every 5° above 62° add 1 per cent to the amount of carbonic acid calculated as above, and deduct the same percentage for every 5° below 62°.

If the place of observation is much above the sea-level, a correction must also be made for the difference of atmospheric pressure. The standard barometric pressure being 30, the formula for this correction is as follows:—

30 : (observed height of barometer) : : capacity of jar : z. The result expressed by z is substituted for the actual capacity of the jar in the calculation for carbonic acid.

Amongst various popular tests for the estimation of the carbonic acid in air vitiated by respiration, the following, proposed by Dr. Angus Smith, is worthy of notice, because it does not require skilled manipulation, nor is it hampered with troublesome measurements or calculations. The method is based upon the fact that the amount of carbonic acid in a given quantity of air will not produce a precipitate in a certain given quantity of lime water, unless the carbonic acid is in excess. This will be better understood by comparing the different columns in the subjoined table, which is taken from Dr. Smith's work on *Air and Rain* :—

Easiest Proposed Household Method.

Table.—*To be used when the point of observation is "No precipitate."* Half an ounce of lime water containing ·0195 gramme lime.

Air at 0° C. and 760 Millim's bar.

Carbonic acid in the air. Per cent.	Volume of air in cubic centimetres.	Size of bottle in cubic centimetres.	Size of bottle in ounces avoirdupois.
·03	571	584	20·63
·04	428	443	15·60
·05	342	356	12·58
·06	285	299	10·57
·07	245	259	9·13
·08	214	228	8·05
·09	190	204	7·21
·10	171	185	6·54
·11	156	170	6·00
·12	143	157	5·53
·13	132	146	5·15
·14	123	137	4·82
·15	114	128	4·53
·20	86	100	3·52
·25	69	83	2·92
·30	57	71	2·51

Columns 1 and 2 give the ratio of carbonic acid in the quantity of air which will produce no precipitate in half an ounce lime water; column 3 is the same as column 2, with the addition of 14·16 cubic centimetres, or half an ounce, to give the corresponding size of bottle; and column 4 gives the size of bottle in ounces avoirdupois. It will thus be seen that different-sized bottles containing half an ounce of lime water will indicate approximately the ratio of carbonic acid in the air contained in them, by giving no precipitate when the bottle is well shaken. Thus, if a bottle of $10\frac{1}{2}$ oz. is used, and there is no precipitate, it will indicate that the ratio of carbonic acid does not exceed ·06 per cent; or if one of 8 oz. is used, and there is also no precipitate, it will indicate that the ratio does not exceed ·08, and so on. Dr. Smith says that "the lime water may be prepared of the same constant strength so closely that we may neglect the difference. Burnt lime is slaked with water, and dissolved by shaking. It is then kept in a bottle to stand till it is clear. The bottle or bottles used should be wide-mouthed, so that they can be readily cleaned and dried, and the air to be examined may be made to enter them by inhaling the air contained in them through a glass or caoutchouc tube, care being taken not to breathe into the bottle."

As a practical application of this method, which can be practised by any one, Dr. Smith proposes the following rule:—"Let us keep our rooms so that the air gives no precipitate when a $10\frac{1}{2}$ oz. bottleful is shaken with half an ounce of clear lime water."

2. *Organic Impurities.*—To obtain an approximate estimate of the organic impurities, the air may be drawn through, or washed, in a very dilute solution of potas-

sium permanganate of known strength. The result is stated in the number of cubic feet of air which it takes to decolorise ·001 gramme of the potassium permanganate in solution. The method at present pursued by Dr. Angus Smith is somewhat different from this. He takes about 30 cubic centimetres of pure water, and adds to it a small amount of known solution of the potassium permanganate. This solution is shaken up with the air in the bottle; the air is then drawn out by a bellows-pump, and another bottleful washed, and so on until the whole colour is removed, or a sufficient amount to enable him to test the remainder, so as to be able to estimate the difference. The actual amount of oxygen taken is then calculated, and the results stated in grains per million cubic feet of air.

3. *Ammonia.*—The estimation of the ammonia, organic and albuminoid, is a still more delicate and difficult process. The water used for washing the air must be perfectly pure, and should therefore be boiled with soda or potash before distillation. From 30 to 50 cubic centimetres are then introduced into a bottle of about 2000 cubic centimetres, and the washing of successive bottlefuls of the air to be examined is continued, until the water is sufficiently charged with impurities. The testing afterwards is the same as that proposed by Messrs. Wanklyn, Chapman, and Smith, for organic impurities in water, and the results are stated in grains per million cubic feet of air.

For further information concerning these methods of analysis, and for an account of numerous valuable experiments, see Dr. Angus Smith's work already quoted.

Section IV.—Microscopical Examination.

Suspended matters contained in the air may be collected by drawing the air through distilled water by means of an aspirator, by washing the air in distilled water, or by employing an instrument called an aeroscope. When either of the first two processes is employed, the suspended matters are merely allowed to subside, and are then removed to a glass slip for examination. The aeroscope invented by Pouchet consists of a funnel-shaped tube, ending in a fine point, beneath which is placed a slip of glass moistened with glycerine. Both glass and tube are enclosed in an air-tight chamber, which is connected by tubing with an aspirator, so that when the stopcock of the aspirator is turned, and the water allowed to escape, the air is drawn through the tube, and impinges against the slip of glass moistened with glycerine, by which the suspended matters are arrested.

Section V.—Examination as regards Temperature and Moisture.

1. *Temperature.*—The various points connected with the temperature of the contained air, such as its equability, sufficiency, etc., are readily ascertained by a judicious distribution of thermometers throughout the space to be examined, and by comparing the outside with the inside temperature. The efficiency of the heating apparatus is of course best tested during very cold weather and in the night time When open fire-places are used, the temperature should be noted at the remote parts of

the room, and if the air is heated before entering, it is advisable to take the temperature at the point of delivery, and to ascertain whether it is well diffused or not.

2. *Moisture.*—The amount of watery vapour, or the hygrometricity of the contained air, may be determined by hair hygrometers, or by wet and dry bulb thermometers. The latter are the most convenient and reliable, but they should be distributed some two or three hours before the observations are made. The wet bulb is covered with muslin, over which there is twisted a small skein of cotton, which dips into a little vessel containing either distilled or rain water. The cotton should be boiled in ether, or soaked in a solution of sodium carbonate, to free it from fat, so that the water may readily ascend by the force of capillary attraction.

Unless the air is saturated with moisture, the temperature of the wet bulb is always below the temperature of the dry, and the number of degrees of difference between them varies according to the amount of watery vapour present. This is generally represented in relative terms. For example, the point of complete saturation being assumed to be 100, any degree of dryness may be stated as a percentage of this, and can be conveniently ascertained by reference to the following table which has been calculated from Mr. Glaisher's large tables (see *Parkes' Manual of Practical Hygiene*). The table is read by taking the temperature of the dry bulb, and the difference between it and that of the wet bulb, and noting the number given at the intersection of the two columns. This number gives the relative humidity.

TABLE *of the Relative Humidity given by the difference between the Dry and Wet Bulb.*

Temperature of the Dry Bulb.	DIFFERENCE BETWEEN THE DRY AND WET BULB.															
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
	RELATIVE HUMIDITY, SATURATION = 100.															
90	100	95	90	85	81	77	73	69	65	62	59	56	53	50	47	44
89	100	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
88	100	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
87	100	95	90	85	81	77	73	69	65	61	58	55	52	49	46	43
86	100	95	90	85	80	76	72	68	64	61	58	55	52	49	46	43
85	100	95	90	85	80	76	72	68	64	61	58	55	52	49	46	43
84	100	95	90	85	80	76	72	68	64	60	57	54	51	48	45	43
83	100	95	90	85	80	76	72	68	64	60	57	54	51	48	45	42
82	100	95	90	85	80	76	72	68	64	60	57	54	51	48	45	42
81	100	95	90	85	80	76	72	68	64	60	56	53	50	47	44	41
80	100	95	90	85	80	75	71	67	63	59	56	53	50	47	44	41
79	100	95	90	85	80	75	71	67	63	59	56	53	50	47	44	41
78	100	94	89	84	79	75	71	67	63	59	56	53	50	47	44	41
77	100	94	89	84	79	75	71	67	63	59	56	53	50	47	44	41
76	100	94	89	84	79	75	71	67	63	59	55	52	49	46	43	40
75	100	94	89	84	79	74	70	66	62	58	55	52	49	46	43	40
74	100	94	89	84	79	74	70	66	62	58	55	52	48	45	43	40
73	100	94	89	84	79	74	70	66	62	58	54	51	48	45	42	40
72	100	94	89	84	79	74	69	65	61	57	54	51	48	45	42	39
71	100	94	88	83	78	73	69	65	61	57	53	50	47	44	41	38
70	100	94	88	83	78	73	69	65	61	57	53	50	47	44	41	38
69	100	94	88	83	78	73	68	64	60	56	53	50	47	44	41	38
68	100	94	88	83	78	73	68	64	60	56	52	49	46	43	40	37
67	100	94	88	83	78	73	68	64	60	56	52	49	46	43	40	37
66	100	94	88	83	78	73	68	64	60	56	52	48	45	42	40	37
65	100	94	88	83	78	73	68	63	59	55	51	48	45	42	39	36
64	100	94	88	82	77	72	67	63	59	55	51	48	45	42	39	36
63	100	94	88	82	77	72	67	63	59	55	51	47	44	41	38	35
62	100	94	88	82	77	72	67	62	58	55	50	47	44	41	38	35
61	100	94	88	82	77	72	67	62	58	54	50	47	44	41	38	35
60	100	94	88	82	76	71	66	62	58	54	50	46	43	40	37	34
59	100	94	88	82	76	71	66	61	57	53	49	46	43	40	37	34
58	100	93	87	81	76	71	66	61	57	53	49	46	43	40	37	34
57	100	93	87	81	75	70	65	61	57	53	49	45	42	39	36	33
56	100	93	87	81	75	70	65	60	56	52	48	44	41	38	35	32
55	100	93	87	81	75	70	65	60	56	52	48	44	41	38	35	32
54	100	93	86	80	74	69	64	59	55	51	47	43	40	37	34	31
53	100	93	86	80	74	69	64	59	55	51	47	43	39	36	33	30
52	100	93	86	80	74	69	64	59	54	50	46	42	39	36	33	30
51	100	93	86	80	74	68	63	58	54	50	46	42	38	35	32	29
50	100	93	86	80	74	68	63	58	53	49	45	41	37	34	31	29
49	100	93	86	79	73	67	62	57	53	49	45	41	37	34	31	28
48	100	93	86	79	73	67	62	57	52	48	44	40	36	33	30	
47	100	93	86	79	73	67	61	56	51	47	43	39	36	33	30	
46	100	93	86	79	73	67	61	56	51	47	43	39	35	32	29	
45	100	92	85	78	72	66	60	55	50	46	42	38	34	31	28	
44	100	92	84	78	71	65	59	54	49	45	41	37	34	31	28	
43	100	92	84	78	71	65	59	54	49	45	41	37	34	31	28	
42	100	92	84	78	71	64	60	54	49	44	40	36	43	30	27	
41	100	92	84	77	70	64	58	53	48	43	39	35	31	28		
40	100	92	84	77	69	63	57	51	46	42	38	34	31			
39	100	92	84	77	69	63	57	52	47	42	38	34				
38	100	91	83	75	68	62	56	50	45	41	37					
37	100	91	83	75	68	61	55	49	44	39						
36	100	91	82	74	66	59	53	47	42							
35	100	90	80	72												
34	100	89	79	72												
33	100	89	78	70												
32	100	87	75													

The relative humidity of the air out of doors should also be ascertained at the same time, by way of comparison.

Concluding Remarks.—This subject has been entered into somewhat fully, because the whole question of ventilation, as regards some of its most important essentials, is still a matter of dispute. Further experimentation, combined with the observation of corresponding health-results, is very much required; and as the numerous work-houses and prisons throughout the country afford ample opportunities for investigation, it is to be hoped that extended inquiry will eventually put the disputed points on a more settled footing. The method of examination, however, must be systematic and experimental, in order to compare results, because the evidence of the senses, however practically useful in most cases, cannot be relied on as a scientific expression of individual opinion.

In the examination of the air contained in the crowded dwellings of the poorer classes, the senses will alone sufficiently indicate the degree of impurity, but in all cases the cubic space per head, and the means of ventilation, should be carefully noted, because otherwise any suggestions as regards improvements will at the best be haphazard, and possibly ill-advised.

CHAPTER VI.

WATER.

Section I.—Sources.

All supplies of fresh water are derived from the condensation of the aqueous vapour contained in the atmosphere. Whether this falls to the earth in the form of rain or snow, a certain portion of it runs off the surface and gravitates towards the sea; another portion sinks into the soil, and, passing through strata which are more or less porous, or through fissures in rocks, again reappears in springs and wells; a third portion is evaporated where it falls; and the remainder becomes absorbed in the chemical composition of minerals, or is utilised in the processes of growth and decay of animal and vegetable life.

The rainfall which flows on the surface collects in streams, lakes, and rivers, according to the conformation of the ground, while the water flowing under ground oozes to the surface either imperceptibly or in springs, and eventually unites with the surface water in its accumulation in lakes, or in its onward progress towards the sea.

The immediate sources of water-supply may therefore be classified as, rain water and water from springs, wells, rivers, or lakes.

1. *Rain Water.*—Rain water is highly aerated, and, when uncontaminated by the receiving surface or by air-

impurities, is healthy and pleasant. It carries down from the air ammoniacal salts, sodium chloride, calcium compounds, and traces of organic matter; the total amount of solids being between 2 and 3 grains per gallon. In this country it is seldom stored except for washing purposes, but in Venice and many other continental cities it is collected in underground reservoirs, and constitutes almost the sole source of fresh-water supply to the inhabitants. It is usually collected from the roofs of houses, and occasionally from paved or cemented ground. In hilly districts with deep ravines, it may be stored by carrying an embankment across a valley, or, in level districts, by digging a series of open trenches leading to a tank or reservoir.

The amount of water derivable from the rainfall in given cases is readily ascertained, if the mean annual rainfall of the district is known, and the dimensions of the receiving area are obtained. Thus, when the roofs of houses constitute the receiving area, the transverse section of the buildings will be one factor, and the mean annual rainfall the other. It has been estimated that the quantity which can be collected from the roof surface of any town in this country will scarcely amount to 3 gallons per inhabitant daily, assuming that the average rainfall is 30 inches, and that house accommodation gives a roof area of 60 square feet for each individual.

If lines be drawn through the sources of the tributaries of rivers marked on a map, they will be found to form the boundaries of certain areas which are called the catchment basins of the various rivers—that is, the areas which receive the rainfall supplying their waters. In compact formations, where most of the rain runs off the surface, the ridge lines bounding these basins usu-

ally pass along the most elevated regions, but in porous formations their course will depend on the configuration of the retentive substratum.

The amount of rainfall which penetrates beneath the surface varies according to the density and configuration of the ground, and also depends on whatever influences the rate of evaporation. Thus, in loose sandy or gravelly districts, as much as 90 to 96 per cent sinks into the soil; in chalk districts, 42; in limestone, 20; while in districts of retentive, impermeable clay, the percentage is very small. Dr. Dalton, in his experiments on the new red sandstone soil of Manchester, found that 25 per cent of the whole rainfall penetrated to the depth of 3 feet; and Mr. Prestwich gave the amount of infiltration of the principal water-bearing strata surrounding London as varying from 48 to 60 per cent.

Other things being equal, the amount of infiltration will be far less in an undulating, hilly district, than in open, level plains. It is obvious also that it must vary very considerably with the season of the year. Thus, according to the experiments of Mr. Dickinson, made in the gravelly loam which covers the chalk in the valleys around Watford, it was 70 per cent in the first three months of the year; in the summer months it was only 2; while in November and December nearly the whole of the rainfall penetrated beneath the surface.

2. *Water from Wells, Springs, Rivers, and Lakes.*—The quality and composition of the water derived from these sources, depend on the nature of the soil and geological strata through which it has passed, or on the character of its surface-bed or channel. The rain, already charged with carbonic acid in its passage through the lower regions of the atmosphere, becomes

still more largely impregnated with this gas when it sinks beneath the surface. In some rich soils, the amount present in the air contained within their interstices, according to Boussingault, is 250 times greater than the ordinary atmospheric ratio. Aided by the action of the carbonic acid which it has thus absorbed, the rain water dissolves and decomposes various chemical compounds which it meets with in its underground progress, and often becomes so highly charged with them as to become unfit for ordinary use, as in the case of mineral waters.

(1.) Surface or shallow well waters, though sometimes comparatively pure, frequently contain a large amount of organic matter. In mossy moorland districts, for example, or in rich vegetable soils, the water may contain from 12 to 30 grains of vegetable matter per gallon, which imparts to it a yellowish or brownish tint. In inhabited places, again, it may become contaminated with animal products, and often contains sodium and calcium nitrates, nitrites, phosphates, sulphates, and chlorides, while in marshy districts organic matter is present in large quantities, varying from 10 to 100 grains per gallon.

(2.) The water from deep wells and springs varies according to the geological strata through which it passes. Thus alluvial waters are more or less impure, containing a large amount of salts (20 to 120 grains per gallon), and often much organic matter; while the chalk waters are clear, wholesome, and sparkling, holding in solution a considerable amount of calcium carbonate besides other salts, and being largely impregnated with carbonic acid. Also wholesome and agreeable to the taste, but not so suitable for cooking purposes, is the

water from the limestone and magnesian limestone strata. It contains more calcium and magnesium sulphate than the chalk water, and consequently does not become so soft on boiling. Waters from the granitic, metamorphic, trap-rock, and clay-slate formations are generally very pure, and contain but small quantities of solids, consisting chiefly of sodium carbonate and chloride, with a little lime and magnesia. Waters from the millstone grit and hard oolite are also very pure. They contain from 4 to 8 grains of mineral matter per gallon, chiefly in the form of calcium and magnesium sulphate and carbonate, with traces of iron. Soft sand-rock waters, loose sand and gravel waters, and waters from the Lias clays, vary very much in quality and composition, some of them being very pure, as the Farnham waters, and others containing large amounts of mineral and organic matters.

(3.) River water is in most cases softer than spring or well water. It contains a smaller amount of mineral salts, but is often more impregnated with organic matter, on account of the vegetable *debris* and animal excreta which find their way into it. Its constant movement, however, facilitates the oxidation of organic impurities, and this purifying process is greatly aided by the presence of fresh-water plants.

(4.) Lake water, especially in mountainous districts composed of the older rock formations, is generally very soft, containing little mineral matter; but as it is essentially a stagnant water, and as all lakes receive the washings of the districts in which they are situated, the amount of organic nitrogenous matter is sometimes very high.

Section II.—Quantity necessary for Health and other purposes.

A healthy adult requires daily from 70 to 100 oz. of water for the processes of nutrition, about one-third of which is contained in articles of diet, the other two-thirds being supplied in the form of liquids. The amount for cooking has been estimated at from half-a-gallon to a gallon daily for each person, while the quantity deemed necessary for personal cleanliness and for washing purposes will necessarily vary very much according to the habits of the individual.

Dr. Parkes gives the following quantities used by a man in the middle class :—

	Gallons daily.
Cooking	·75
Fluids as drink	·33
Ablution, including a daily sponge-bath .	5
Share of utensil and house washing . .	3
Share of clothes washing	3
	12·08

The soldier is allowed 15 gallons daily, no extra allowance being given for the women and children in a regiment. In the poorer districts of the city of London, Dr. Letheby found that the amount used was 5 gallons per individual daily, and in model lodging-houses, according to Mr. Muir, 7 gallons. A shower-bath daily will require 3 to 4 gallons, while a plunge-bath will take from 40 to 60 gallons. Where water-closets are used, an additional allowance of from 4 to 6 gallons must be provided. Latrines require a less amount.

In gross amounts Professor Rankine gives an estimate of 10 gallons daily per individual for domestic

purposes, 10 for municipal purposes, and 10 more for trade purposes in manufacturing towns, and this amount, large though it seems, is actually supplied to many towns at the present day. Glasgow, for example, receives 35 gallons daily per head of population; Edinburgh and Southampton 35; Paris 31; and Liverpool 30. The different London water companies supply from 21 to 34 gallons, while the manufacturing towns in Lancashire and Yorkshire, according to Mr. Bateman, received from 16 to 21 gallons. Mr. Rawlinson's minimum estimate for manufacturing towns is 20 gallons per head daily.

In apportionating the daily allowance for all purposes, Dr. Parkes has given the following estimate:—

	Gallons per head of population.
Domestic supply	12
General baths	4
Water-closets	6
Unavoidable waste	3
Total house supply	25
Municipal purposes	5
Trade purposes	5
Total	35

No doubt this estimate of Dr. Parkes may be regarded as somewhat excessive, especially in the items of domestic and water-closet supply, but it has been based on the principle that a liberal allowance is not only necessary for thorough cleanliness, but that it is also required for an efficient clearage of sewers. Many engineers are of opinion that the great waste which is sometimes complained of is owing to water-closets; and in towns with a constant supply, small cisterns, termed water-waste preventers, have been in-

troduced, to permit only a certain amount of water to flow into the pan each time the closet is used. The great objection to them is, that they are generally too small, so that neither the pan nor soil-pipe is thoroughly flushed, and there is the consequent risk of filth-accumulation. Where water is scarce it may be necessary to enforce rigid economy, but where it can be procured plentifully, it is far better that any error in the amount of supply should be on the side of excess.

For hospitals the daily amount per patient may be estimated at about 30 or 40 gallons. In prisons and workhouses the quantity will vary according to the bathing arrangements, and whether water-closets are used. In the Convict Prison, Portsmouth, where water-closets and water-latrines are both in use, and where each prisoner is allowed a general bath once a week, the amount averages about 11 gallons per convict daily.

Section III.—Modes of Supply.

This part of the subject has reference to wells, borings, the collection and storage of water, and to water-works generally.

1. *Wells and Borings.*—Most surface wells are sunk into a bed of sand or gravel resting upon an impermeable stratum of clay. If the surface of the clay basin is very irregular, as is commonly the case, it is impossible to predict at what depth the water will be reached, or at what level it will permanently stand. Theoretically, it may be inferred that the superincumbent stratum of sand or gravel is situated below the level of the lowest point at which the water can escape from the clay basin; and hence, in digging such wells,

it is only necessary to reach the line of saturation to find water.

In sparsely populated districts these surface wells constitute the usual source of supply, and if proper precautions be taken to guard against the soakage of animal excreta into them, they usually yield a wholesome water; but in villages and towns the soil often becomes so saturated with impurities that it is next to impossible to prevent their pollution. In crowded localities, therefore, they should always be regarded with suspicion, and, as far as possible, their use should be discontinued. Deep wells, on the other hand, are not open to this objection, because they are generally sunk through an impervious stratum, which prevents the infiltration of any surface impurities, and at the same time serves to keep down the water in the porous strata beneath. The quality of the water from these wells, as has already been shown, will depend on the nature of the geological formation of the district. It is also apparent that, in accordance with a well-known physical law, it is only necessary to bore through the impervious stratum, and reach the water-bearing bed, for the water to rise to the surface, or to within a short distance of it, so as to be collected in a well of ordinary dimensions. Indeed, in certain low-lying districts, where a boring is made at a point considerably below the level of the line of infiltration into the water-bearing stratum, the water rises above the surface and overflows. Such overflowing wells, or artesian wells, as they are called, were once common in the valley of the Thames, and are still to be met with in the flat lands of Essex and on the coast of Lincolnshire. Ordinary borings differ from artesian wells in not piercing through a retentive stratum in

order to reach the water-supply. They are very common in the chalk and new red sandstone districts, and are made to increase the yield of the wells. Practically, it is found that one boring adds to the supply of a well nearly as much as several. Thus in the Bootle well at Liverpool, with 16 bore-holes, some of which were 600 feet deep, Mr. Stephenson found that when all were plugged up but one, the yield was 921,192 gallons per day, and when all were open it was only increased by 112,792 gallons.

Deep wells are now being abandoned for the supply of large towns, because they are found to be insufficient for the wants of a growing population, and obviously cannot be multiplied within a given district beyond certain limits, because every single well drains a surrounding area of some considerable extent. For large isolated buildings, however, such as lunatic asylums, workhouses, and prisons, they usually supply the whole of the water required; and in selecting a site in the country for any such building, the possibility of obtaining the requisite water-supply, and the cost at which it can be procured, are points of the first importance.

Generally speaking, the chance of obtaining a good supply will depend upon the nature of the underlying strata, and upon the level of the proposed site. Wells sunk in superficial sand or gravel beds, though yielding a good supply at ordinary times, are very liable to have their yield very much lessened in seasons of drought, unless they are situated at points considerably below the level of the surrounding country, and the same remark applies to wells in the chalk districts. On the other hand, wells or borings in the new red sandstone and limestone formations usually yield a large and constant

supply, because these permeable rocks are so saturated with water that they may be regarded as vast subterranean reservoirs. The deepest artesian wells in the world are those at Grenelle in Paris and Kissengen in Bavaria, the former being 1800 and the latter 1878 feet in depth.

For a small or temporary supply the American tube well (Norton's patent) has been found to be very useful. It consists of a narrow iron tube driven into the ground in lengths, the lower part being pointed and perforated at its end, and is fitted with a single or double action pump according to the depth. The water enters the tube through the perforations, and, if the bed is sandy, has to be filtered for some time, until, by gradual removal of the sand, a well is formed around the lower end, and the water is obtained without sediment.

In order to ascertain the yield of wells, the water must be pumped out, and the time noted which is required for refilling. The yield of small springs can be readily measured by receiving the water into a vessel of known dimensions, such as a cask, and also noting the time which it takes to fill.

2. *Water-Works.*—Water-works on an extensive scale obtain their supply from lakes, streams, rivers, or gathering-grounds. If from a lake of sufficient elevation above the level of the town to be supplied, the water may be distributed throughout the town in conduits and pipes by the force of gravity. When the source of supply is a stream or small river, storage works are necessary; but when the river is large, a constant supply can be obtained at all times, independently of storage. In this case, the works required

usually comprise—a weir or dam for maintaining part of the river at a nearly constant level; two or more settling-ponds, into which the water is conducted; filtering apparatus, and pumping engines.

When it is required to ascertain the yield of any small stream, it is usual to employ a weir-gauge to dam up the water into a pond behind, and allow it to flow through certain orifices of known dimensions. In the case of an average-sized stream, a rough approximation of the yield may be obtained by taking the breadth and depth at several distances in a short section of the channel which is tolerably uniform, and thus ascertaining the average sectional area. The surface-velocity may then be taken by noting the time occupied in floating a light object over the selected distance, and as four-fifths of the surface-velocity are about equal to the actual velocity, the yield in cubic feet or gallons per second can be easily calculated.

When the water-supply of a town is collected from small streams or gathering-grounds, the rainfall of the catchment basin and its available amount are items which ought to be carefully inquired into. The ratio of the available to the total rainfall, as already shown, is influenced by the nature of the soil, the steepness or flatness of the ground, the rapidity of the rainfall, and other circumstances. Professor Rankine gives the following examples:—

Ground.	Available Rainfall divided by Total Rainfall.
Steep surfaces of granite, gneiss, and slate, nearly	1
Moorland hilly pastures -	from ·8 to ·6
Flat cultivated country -	from ·5 to ·4
Chalk - - - - -	0

The average annual rainfall in different parts of this country varies from 22 to 140 inches, the least recorded depth being 15 inches. It is greater in mountainous than in flat districts, and on the leeward side of a mountain ridge than it is on the side facing the prevailing winds. As regards water-supply, the most important data are the least annual rainfall and the longest period of drought.

In selecting drainage areas, it must be borne in mind that the nearer the actual rainfall water is collected, the freer it will be from impurities, and that purity of water and fertility of soil are not to be expected together. Water collected from a peaty soil will contain large quantities of vegetable matter, while that from a soil well cultivated will be tainted with animal impurities. The purest water, therefore, which can be collected from drainage areas is found in the barren moorland districts of the primary geological formations, or of the sandstone rocks.

The channels of the gathering-ground may either be the natural watercourses of the district, or these may be supplemented by closed drains or open ditches. The latter, however, are objectionable, because they form receptacles for vegetable matter, and as the current in them must be necessarily slow, there is considerable loss by evaporation. The position, extent, and dimensions of the drains leading to the reservoir will depend upon the configuration of the district. The reservoir itself is generally a natural hollow, situated in the valley-line of the catchment basin, and of sufficient elevation to procure a fall, so that the water can be distributed without mechanical means being required to raise it. In this country the storage-room should be

large enough to contain a four or six months' supply; and the site which can supply the requisite storage-room with the least embankment and the least area laid under water is to be preferred.

Upon the strength and stability of the embankment everything depends. It is made water-tight by a core of clay puddle, the inner slope being protected from the action of the water by a pitching of dressed stones, and the outer, from the effects of the weather by a covering of grass sods. The puddle-core generally amounts to a tenth of the whole embankment. The height of the embankment varies from 3 to 10 feet above the highest water-level, the top being covered with broken stones. No trees or shrubs are allowed to grow upon it, and the greatest care is taken in its construction, to prevent animals, such as water-rats, burrowing into it.

Every impounding reservoir, as it is called, is provided with an overflow weir to permit the discharge of the flood-supply from the drainage area, and this is often supplemented by a channel termed the *bye-wash*, which is used to divert the streams supplying the reservoir, so as to prevent fouling of the store-water. The flood-water carried off in this way flows into the natural watercourse.

In order to remove the sediment which collects in the bottom of the reservoir, there is always a cleansing pipe as well as a discharge pipe, the former being on a level with the lowest point in the reservoir, and discharging into the natural watercourse below the embankment. Both are carried through a culvert in the embankment, which is built of stone or brick, and founded on the solid rock. The aqueduct or discharge pipe bends upwards in the reservoir, and has a series

of inlets, the lowest at the lowest working level, and the whole of them guarded against the entrance of small stones, pieces of wood, or other bodies, which would interfere with the action of the valves. The sluices, which are required for both pipes, are situated in the reservoir, and are worked from the sluice-tower.

The aqueduct is that portion of the conduit leading from the reservoir to the distributing conduits. It may be open or close throughout, or partly close and partly open. If close, it generally consists of a train of cast-iron pipes securely jointed, bedded on a firm foundation, and covered to a depth of at least 2 or 3 feet, to preserve them from frost. Sluice stop-cocks are provided in the valleys, for the purpose of scouring out any stones or sediment, and, at intervals not exceeding half a mile, to permit of repairs. Valve-cocks are supplied at all the principal summits, to allow the escape of air. When the aqueduct is partly close and partly open, or if, when close, it cannot withstand the whole pressure when the demand ceases, either a system of weirs is required to discharge the surplus water, or a second store-reservoir is provided, resembling, in general plan and construction, the impounding reservoir.

The distributing conduits also consist of cast-iron pipes, and are coated, like the aqueduct pipes, with pitch to preserve them from corrosion. The same details with regard to sluice-cocks and stop-cocks are observed in the different bends of the tracks, with this addition, that the dead ends or terminations of the branch and main conduits are supplied with scouring valves through which stones and sediment can be washed. In wide streets, or in streets with much traffic, there is generally a service-pipe for each side, in order that the house-pipes may be

as short as possible, and may be accessible without disturbing the traffic. The house service-pipes are usually made of lead, and though they are liable to be acted upon by some waters, the readiness with which they can be adapted to all the bends and curves rendered necessary in carrying the piping to different floors of houses, gives them a preference to all other kinds of metal pipes. The waters which act most on lead are the most highly oxygenated, and those which contain organic matter; those which act least on it contain carbonic acid, calcium carbonate, and calcium phosphate. Various means have been proposed to protect the lead from corrosion, such as coating with bituminous pitch or with coal tar; but when the quality of the water renders lead pipes objectionable, cast and wrought iron pipes make the best substitutes, or the leaden-cased block-tin pipes patented by Mr. Haines in 1870. These pipes consist of a separate tube of pure block-tin encased in lead, and the union of the two is so perfect that no amount of torsion will separate them. They have been highly spoken of, as satisfying every sanitary requirement, by Drs. Letheby, Lankester, and others.

As the greatest hourly demand for water is about double the average hourly demand, the main conduits supplying a town must have double the discharging capacity which would be required if the hourly demand were uniform. The additional expense in piping which would be thus entailed is sometimes so great, that distributing basins or town-reservoirs are constructed to supply certain districts. To meet all emergencies, they are made large enough to contain at least a day's supply, and they must also have a site of sufficient elevation to ensure distribution by hydrostatic pressure. Every such

reservoir should be roofed in and ventilated, to protect the water from frost and heat, and from becoming tainted with aerial impurities.

The water thus distributed to the various houses in a district is supplied either on the intermittent or constant system. The intermittent system necessitates storage in house cisterns, and is attended by so many disadvantages, that sanitary engineers are for the most part unanimous in recommending the constant system wherever it can be carried out. The use of cisterns, except on a small scale for water-closets and boilers, is open to the great objection of the risk of contamination of the water, for not only are the cisterns liable to become fouled if not sufficiently protected against the entrance of aerial impurities, but the water is apt to become tainted with sewer-gases, which may enter the cistern through the overflow pipe. Moreover, in poorer districts, the cisterns are often of a very inferior description, are badly situated, and are seldom inspected or cleaned out. To meet this objection, it has been proposed to have one large tank for the supply of a group of houses,—the tank to be under the immediate inspection of the waterwork officials, and to be filled daily, and the householders to be supplied through small pipes constantly charged. It is further urged against the intermittent system, that the distribution pipes, being alternately wet and dry, are liable to collect dust and the effluvia from sewers or drains. The objections to the constant system, on the other hand, are the great waste when the fittings are imperfect, and an insufficient delivery when the water-supply is not abundant. The diameters of the pipes for constant service should therefore be carefully adapted to their

discharges and to the head of pressure; the drawing taps ought to be valve-cocks to open and shut with a screw; and the town should be efficiently provided with distributing basins, so that an extra flow of water in one district would not interfere with the requisite supply of other parts. When the water is raised by pumping, and there is no reservoir, the constant system is impracticable.

In order to prevent undue waste, water-meters are sometimes applied to the service-pipe supplying a group of houses, and the landlord charged for the amount used; but as this plan induces the landlord to enforce a too rigid economy, it is not to be commended. The best water-meters are capable of registering exactly all amounts exceeding a flow of one gallon per hour.

The waste-preventer, or small cistern for the supply of water-closets, which has already been alluded to, should at least hold 2 gallons. The smallest waste-preventers hold $\frac{3}{4}$ of a gallon, but this quantity is insufficient to flush the pan and soil-pipe properly.

Another plan for effecting economy in the constant system, proposes that a cistern, large enough to hold a twenty-four hours' supply, be provided for each house, and that the service-pipe shall be of a diameter to deliver the required quantity during that time, and nothing more. Every cistern supplied in this way would become gradually emptied during the day time, and would be refilled during the night; but the plan is open to the great objection attaching to the intermittent system, and does not sufficiently provide for emergencies.

Wherever cisterns are employed, they should be so situated that they can be readily cleaned out when necessary. The best materials for their construction are slate-slabs well set in cement, or galvanised iron.

Leaden cisterns, unless lined with a coating of pitch, tar, or other preservative substances, are objectionable. All cisterns should be covered in, and protected from heat and frost. The inlet to every cistern ought to have a cock, with a float to rise and stop the supply when the cistern is full; and when the supply is constant, the overflow should be so arranged as to become a nuisance. An overflow pipe from a cistern should never lead directly into a sewer, but should end above ground over a trapped and ventilated grating. If this were always attended to, no sewer-gases could find their way to the cistern through this channel.

In addition to the arrangements for domestic supply, outlets or hydrants with valve-cocks are provided on the service-pipes of all large towns, at regular intervals, in case of fire, and for supplying water to flush the gutters and water the streets.

Section IV.—Purification of Water.

On an extensive scale the process of purification is carried on by means of filtration, the water being received into large filter-beds previous to its distribution. A filter-bed may be described as a tank or reservoir several feet in depth, with paved bottom, on which are laid a series of open-jointed or perforated tubular drains leading into a central culvert. The drains are covered with a layer of gravel about 3 feet deep, over which is spread a layer of sand about 2 feet deep. The layer of gravel is coarse at the bottom, becoming gradually finer towards its upper surface, and the same relative gradation, as regards coarseness and fineness, is observed with regard to the sand. The water is delivered uniformly and slowly, and in order

that the filtering process may not be carried on hurriedly, the pressure is always kept low, the depth of water being seldom above 2 feet, and in some cases only 1 foot. The speed of vertical descent should not be much above 6 inches per hour, nor should the rate of filtration much exceed 700 gallons per square yard of filter-bed in the 24 hours, although some water companies filter at a much more rapid rate than this. In large works there are always several filter-beds, to allow of some being cleansed while the others are in use. The sediment deposited on the surface of the sand requires to be scraped off at intervals, and at each cleansing operation about half-an-inch of sand is also removed. A fresh supply of sand is added when the depth of the layer is reduced to an extent which threatens to impair the efficiency of the filter. It appears that proper filtration, carried on according to this plan, removes suspended impurities, and a certain amount of dissolved mineral substances, but whether dissolved organic matters are destroyed, or oxidised to any considerable extent, seems doubtful.

Small filters for domestic use may be placed in the cistern, in the course of the delivery pipe, or they may be filled by hand. As filtering media various substances are used, such as animal or vegetable charcoal, a mixture of fine silica and charcoal, magnetic carbide of iron, sponges, wool, etc. According to Dr. Parkes, the best filters are made either of animal charcoal or magnetic carbide of iron. They are capable of removing almost all the suspended matters, and at least 40 per cent of dissolved organic impurities, together with a considerable amount of salts, such as calcium carbonate and sodium chloride. Indeed, the experiments

of Mr. Wanklyn with the silicated carbon-filter prove that, by repeated filtration, river water containing a considerable amount of free and albuminoid ammonia may be made as pure as deep spring water.

Of filtering media, animal charcoal, properly washed, is now admitted to be in every way the most efficient. It exerts a chemical as well as mechanical action on organic impurities, and Dr. Frankland is so convinced of its value as a filtering agent, that he recommends its employment on a large scale for the purification of town supplies, in spite of the cost which would be entailed.

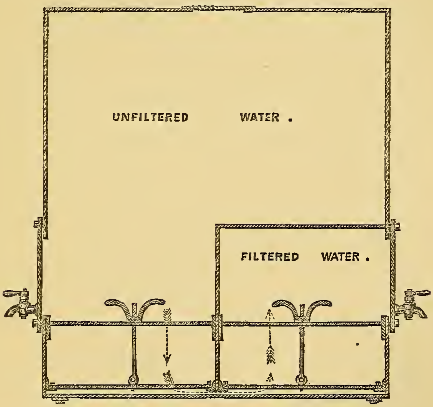
Amongst filters which have been specially commended for their efficiency, may be mentioned the cistern filter of the Water Purifying Company, London; Libscombe's Self-Cleaning Charcoal Filter; the Patent Carbon Block Filter, manufactured by Atkins and Co., London; and the Carbon Cistern Filter, planned by Mr. Finch, of the Holborn Sanitary Works. All of these contain animal charcoal as the filtering medium, and can be applied to any kind of house cistern. The filtering block of the Silicated Carbon Company consists of 75 per cent of charcoal and 22 of silica, with a little iron oxide and alumina. It is cemented into a vessel which it divides into two chambers, the one containing the filtered and the other the unfiltered water. This filter is found to work very efficiently, and with a little care retains its properties for a long time. The filtering material of the Magnetic Carbide Filter is prepared by heating hæmatite with sawdust. The only objection to it is that it communicates a slight taste of iron to the water. The Patent Moulded Carbon Filter makes an elegant article for the sideboard. It consists of two glass ves-

sels, the upper containing the filter-block, and the lower, which can be used as a water bottle, the filtered water. Tap-filters, suited for a high or low pressure, can be fitted to the pipes themselves. They contain charcoal or silicated carbon, and would seem to act very well.

A charcoal filter has lately been introduced by Captain Crease, of the Royal Marine Artillery, which, for simplicity of construction, adaptability to different kinds of water and rates of supply, and for efficiency, deserves special notice. It is known as Crease's Patent Tank Filter, and is manufactured by Mr. Bellamy, of the Tank Works, Millwall, London. It is now largely used in the Navy, and is specially suited for large buildings, such as asylums, workhouses, etc. The tank is made of iron, lined with cement, and is divided into three chambers. The two filtering-boxes which it contains are filled with pieces of animal charcoal, or the one may be filled with animal charcoal and the other with sand and gravel. The upper perforated plates of the boxes are movable, so that by means of screws working on rods attached to the fixed under plates, which are also perforated, the filtering media may be lessened or compressed to any extent, according to the degree of impurity of the water. The water descends through one box into a small chamber at the bottom of the tank, which retains any deposit, and then rises through the second box into the reservoir which contains the filtered water (see fig. 7). The whole of the apparatus can be readily unscrewed, taken to pieces, and cleaned out when necessary, the joints being made water-tight by gutta-percha bands. Smaller filters on the same principle have also been patented by Captain Crease.

All filters after a time become clogged up, and have

therefore to be taken to pieces and thoroughly cleansed; or, if this cannot be easily done, they may be purified by passing through them a solution of potassium permanganate, or Condy's fluid, with the addition of a few drops of strong sulphuric acid, and afterwards two or three gallons of pure or distilled water, acidulated with hydrochloric acid. The charcoal in a filter may also be purified by exposing it for some time to the sun and air, or by heating it in an oven or furnace.



LONGITUDINAL SECTION.

Fig. 7.

The purification of water without filtration is not carried on in this country on the large scale except by Dr. Clark's process. This consists in adding a certain amount of lime water to a water which contains calcium carbonate rendered soluble by the presence of carbonic acid. Spring waters in the chalk districts are all more or less "hard," and many of them contain such a large amount of calcium carbonate in solution as to be unfit for washing purposes. Such a water, when it is to be

rendered "soft" by Clark's process, is let into a tank or reservoir, where it is mixed with a proper proportion of lime water and allowed to settle, the whole of the calcium being precipitated as neutral carbonate. A perfectly clear and wholesome water is thus obtained, well suited for domestic purposes. Calcium carbonate may also be removed by boiling, in which case it is deposited as an incrustation on the inner surface of the kettle or boiler.

Aluminous salts have long been used in Eastern countries to purify water, and are found to be very efficacious in removing suspended matters, whether organic or mineral. Organic matters in solution are best treated with potassium permanganate or Condy's red fluid. It readily removes any offensive odour arising from water kept in casks, and oxidises at least a portion of the organic impurities which may be present; but as albumen is only slightly affected by it without the aid of heat, it cannot be regarded as a reliable purifier of water tainted with animal impurities.

Among other purifying agents may be mentioned, distillation, the exposure of water in minute divided currents to the air, the immersion of pieces of charcoal or of iron wire, and the effects of plants and fish. In store reservoirs, the presence of a moderate quantity of living plants exerts a decidedly purifying influence, while the destruction of fish has been followed by an excessive multiplication of the small crustacean animals on which the fish had lived, thereby rendering the water nauseous and impure. The remedy was found in re-stocking the reservoir with fish. (*Rankine.*)

Section V.—Examination of Water.

As an exhaustive analysis of any given sample of water can only be conducted in the laboratory and by a professed chemist, it would be out of place here to attempt to describe any other than easily applied methods for arriving at a reliable estimate of the qualities of a water, and whether it may safely be used.

In addition to a qualitative examination, it is advisable to make inquiries with regard to the source of the water, and to determine the probability, or otherwise, of its pollution. Wells, for example, which have hitherto yielded a good and wholesome water, may become contaminated with the fluids draining away from recent filth-accumulations, from graveyards, from neighbouring cesspools which have become leaky, or from the bursting of some sewer or drain. Reservoirs or cisterns, again, may become so foul, through neglect of cleansing them at stated intervals, that the water-supply is eventually rendered totally unfit for use, and becomes productive of disease; or the cistern-overflow pipe, should it open directly into a drain, may become the channel for the escape of pent-up sewer-gases, which are, in their turn, absorbed by the water stored in the cistern. In small villages, a sudden rise of the subsoil-water, occasioned by heavy rains following a period of drought, may wash into the wells the soakage from middens, cesspools, or open ditches filled with sewage; or the supply of a large town from a river contaminated with sewage may convey impurities to every household through some temporary inefficiency in the filtering process. All these, and numerous other contingencies, have to be borne in mind, more especially as

regards the possible contamination of a water which is constantly used, inasmuch as it is not sufficient to pronounce such a water unwholesome, without, at the same time, endeavouring to ascertain the source of its pollution.

In collecting water for analytical purposes, and particularly when it is intended that the samples shall be transmitted to a professed analyst for examination, the following directions should be observed:—An ordinary glass-stoppered Winchester quart bottle will answer very well for the conveyance of the water. It should be cleaned out with strong sulphuric acid, then rinsed with ordinary good water until the rinsings are no longer acid, and finally washed out with some of the water to be examined. The bottle should be filled almost up to the neck, stoppered, and the stopper covered over with a piece of clean calico, tied, and sealed. No luting should be used except sealing-wax, and even that should be dispensed with if possible. If the water contains organic matter, it should be examined at least within forty-eight hours after being collected.

In collecting pond or lake water, the bottle should be plunged into the water as far as possible from the bank, with the mouth well under the surface so as to avoid the scum, care being taken, at the same time, that the mud at the bottom is not disturbed. If the sample is taken from a town supply, it should if possible be collected direct from the mains, or from the water-jets at the cab-stands or public fountains, in which case the water should be allowed to flow for some time previous to filling the bottle. If taken from a house service-tap, the water should also be allowed to flow for some time

before collecting. With regard to river water, it is recommended to select the middle of the stream, to avoid the outlets of sewers and feeders, and to note whether there has been previously a heavy fall of rain or a long drought.

Different methods of examination require different quantities; for Mr. Wanklyn's method, one Winchester quart will be sufficient, but Dr. Hassall and others require two. For an ordinary qualitative examination, the chief requisites are that the vessel should be thoroughly clean, and the sample fairly collected.

1. *Physical Examination.*—A portion of the sample collected should be poured, after shaking the bottle, into a good-sized clear glass flask. If the flask is then held in front of a dark-coloured surface, with a good light falling on the side or from above, any suspended impurities will become visible, but care should be taken to discriminate between them and air-bubbles.

Colour and turbidity are best ascertained by pouring the water into a tall vessel of colourless glass, two feet high and one inch in diameter, and placing it upon a porcelain slab or piece of white paper. Another glass of the same dimensions, filled with distilled water, should be placed by its side for comparison. Both samples are then looked through from above, and the difference between them noted. If organic matter is present, the water has usually a tinge of yellow, green, or blue, but mineral substances may give similar indications. Clay, peat, and other harmless contaminations, impart a brownish tint. If the turbidity is considerable, or if the water is very dark in colour, it may be pronounced unfit for use, although filtration may render it perfectly wholesome.

To observe the smell of the water, a portion of it should be poured into a wide-mouthed flask, making it about one-third full, and then shaking it well. If the smell is unpleasant, the water is unfit to drink. Should no smell be detected, the flask should be heated, and the water again shaken, and if there is still no smell, a little caustic potash should be added to the warm water. Any unpleasant odour which may now be given off indicates with tolerable certainty that the water contains organic impurities in considerable quantity. The occurrence of a precipitate on the addition of the caustic potash will, at the same time, indicate hardness.

With regard to taste, it is sufficient to say that a badly-tasting water should be condemned for drinking purposes. Many waters, however, which are largely impregnated with dissolved animal impurities may be quite palatable.

Altogether, the physical examination of water is of a negative character; and although it may impart some useful information, it cannot be relied upon in arriving at a sound conclusion as regards the good or bad qualities of any given sample.

2. *Microscopical Examination.*—In order to collect the sediment, the water should be allowed to stand for 12 or 24 hours. Particles of sand are recognised by their angular shape, and by their not being affected by acids. Particles of clay and marl are amorphous, and are also unaffected by acids. Particles of chalk are amorphous, and are readily dissolved by acid. Dead vegetable matter, such as woody fibre and portions of leaves, and living vegetable matter, consisting of confervoid growths, may all be detected in water which

cannot be pronounced unwholesome. So also may *diatomaceæ, infusoria,* and *entomostraca.* Microscopical examination, therefore, is only valuable in so far as it indicates the various components of the suspended matter. It gives no information concerning the presence of dissolved organic impurities, unless the "zymotic test," as proposed by Dr. Burdon Sanderson, be applied. As this, however, takes several days for completion, and as the information which it conveys can be more readily obtained by easier methods, it need not be described.

3. *Chemical Examination.*

(1.) *Total Solids.*—The amount of total solids is ascertained by evaporating a known portion of the water, along with the sediment, to dryness, and weighing. If the residue in the evaporating dish blackens when it is incinerated over a flame, the presence of organic impurities is indicated, and should a bad smell be given off at the same time, it may be inferred that some of these impurities are of animal origin. Another test for these impurities is to suspend a piece of filtering paper, which has been steeped in a solution of potassium iodide and starch, and afterwards dried, over the dish during incineration; if this becomes blue, it shows that nitrous acid fumes are being given off, which almost always arise from animal, and not from vegetable, matter. According to Dr. Parkes, the total solids in good water should not exceed 8 grains per gallon, unless it be a chalk-water, in which case they should not exceed 14 grains of calcium carbonate. Usable waters may, however, contain as much as 30 grains. The organic matter should scarcely blacken on incineration, or, if the blackening is

considerable, it should be ascertained to be chiefly due to the presence of vegetable matter.

(2.) *Organic Matter.*—Organic impregnation may also be detected by boiling several ounces of the water with a few drops of a solution of gold trichloride, and, in proportion to the quantity present, the gold is reduced, and falls as a violet or dark powder. Another test, which, on the whole, gives more important information, is that of the potassium permanganate. The test solution should consist of two grains of the permanganate to about $10\frac{1}{2}$ oz. of distilled water. About half a pint of the water to be examined is acidulated with a few drops of hydrochloric acid, and the solution slowly added while the water is stirred with a glass rod until a faint pink tinge is perceptible. This can best be observed by using a colourless glass vessel placed on a sheet of white paper, and by looking down through the water on the paper. As every 10 minims of the solution yield $\frac{1}{1000}$ of a grain of oxygen, the amount of oxidisable matter in the water can thus be approximately estimated. The amount of solution required to produce the perceptible tinge should be noted, and at the end of every fifteen minutes a few more drops of the solution are to be carefully added, until the colour remains permanent for half an hour.

The value of this test depends upon the fact that putrid organic matter rapidly decolorises the solution, while that which is less decomposable, and therefore not so injurious, decolorises it more slowly. But as sulphuretted hydrogen (recognisable by its smell), nitrites, and iron, also effect a rapid decoloration, the tests for these should be applied, to ascertain whether or not it is to be attributed to their presence. With

these limitations, therefore, the permanganate test gives valuable information, and when used in conjunction with other tests, a reliable opinion as regards the wholesomeness or unwholesomeness of a water may be confidently given. Rapid decoloration is strongly indicative of direct sewage contamination.

(3.) *Lime.*—Pour a little of the water into a test-glass, and add a solution of ammonium oxalate. Six grains of lime per gallon will yield a slight turbidity; 16 grains, a distinct precipitate; and 30 grains, a large precipitate soluble in nitric acid.

(4.) *Magnesia.*—In a good water there should only be a slight haziness, or none at all, on the addition of ammonia.

An excess of lime or magnesia is evidence of hardness.

(5.) *Lead and Iron.*—Boil between 3 and 4 oz. of the water acidulated with a few drops of sulphuric acid, and afterwards add sulphuretted hydrogen water. If a brown or blackish coloration is produced, the presence of lead may be inferred. If no colour can be detected, add a little potash or ammonia, and if this produces a blackish precipitate, iron is almost certain to be present.

(6.) *Chlorides.*—Acidulate a little of the water in a test-glass with a few drops of dilute nitric acid, and add a solution of silver nitrate. Four grains per gallon of sodium chloride give a turbidity; 10 grains, a slight precipitate; and 20 grains, a considerable precipitate, soluble in ammonia. A good water should only yield a slight haziness. If there is a distinct precipitate, it shows that the water is derived from sand or some formation rich in salt, that it is brackish if on the sea-coast, or that it has been contaminated with sewage.

In the first two cases there will be a large amount of mineral solids, and the last may be decided by confirmatory tests.

(7.) *Sulphates.*—Acidulate with a few drops of hydrochloric acid, and add a solution of barium nitrate. A good water should not give more than a slight haziness.

(8.) *Nitrates.*—Evaporate a pint of the water to about an eighth of its bulk, pour a portion into a test-tube, and add an equal quantity of pure sulphuric acid. When the mixture is cool, hold the tube almost horizontally, and pour in gently a similar quantity of a rather strong solution of ferrous sulphate. Let the tube stand for about half an hour, and if a dark olive-green or brownish ring becomes visible at the line of junction between the iron solution and the acid mixture, the presence of nitrates is indicated. The presence of nitrates is also indicated by the disappearance of the blue colour on boiling another portion of the concentrated water with a few drops of strong sulphuric acid and indigo.

If a water giving these reactions comes from a deep well, it need not be condemned, but if from a surface-well or stream, it should be regarded as suspicious.

(9.) *Nitrites.*—Make a mixture of 1 part of potassium iodide, 20 of starch paste, and about 500 parts of boiling water acidulated with a little acetic acid. Add a little of the mixture, which should be quite clear, to the water; a blue tint indicates nitrites. If the colour is at all deep, the water is scarcely safe to drink.

The presence of nitrates or nitrites in a water is evidence that there has been previous contamination with albuminous matter of some kind, and that such

matter has been so far oxidised. They do not indicate, however, that the whole of the oxidation of the nitrogenous impurities has taken place, and on this account their presence should always be regarded with suspicion, especially in a water at all likely to be contaminated with sewage.

(10.) *Ammonia.*—When the Nessler reagent, which is the best test for the presence of ammonia, can be procured, it should always be used as a confirmatory test for organic impregnation. The test itself is prepared as follows:—Take 35 grammes of potassium iodide, and dissolve in a small quantity of distilled water; add to it a strong aqueous solution of mercury bichloride, and keep constantly stirring until the red precipitate ceases to disappear; filter, and add to the filtrate 120 grammes of caustic soda, or about 160 grammes of potash in strong aqueous solution. After adding the solution of alkali, dilute the liquid with distilled water, so as to make its volume equal to one litre. Add to it about 5 cubic centimetres of a saturated aqueous solution of mercury bichloride; allow to subside; decant the clear liquid into a well-stoppered bottle, and keep it in a dark place. If, after adding a little of this test-solution to between 3 and 4 oz. of the water to be examined, a yellow or brown colour, or a brown precipitate, should be produced, the water contains ammoniacal salts. This is a most suspicious circumstance, and of itself is almost sufficient to condemn the water for drinking purposes.

By a judicious application of a few or several of these tests, and with a knowledge of the source of the water, a confident opinion may in all cases be given as to whether the water is fit for use, or

whether it has been contaminated with sewage or other impurities.

The following is a brief summary of the more important facts connected with the examination of water, together with the practical deductions which may be drawn from them :—

A good and wholesome water, according to Dr. Parkes, should be clear, transparent, well aerated, without taste or smell, and free from suspended matters. Unless it be a chalk-water, the total solids should not exceed 8 grains per gallon, and the residue on incineration should scarcely blacken. The tests for chlorides, sulphates, magnesia, lead, or iron, should either give no reaction or only very slight indications. Nitrites should be absent; and at the most there should only be very trifling indications of the presence of nitrates or ammonia.

A usable water may contain as much as 30 to 50 grains of solids per gallon when these consist chiefly of calcium and sodium carbonates; but the tests for nitrites, nitrates, ammonia, and magnesia, should only give slight reactions, and any organic matters which may be present should be principally of vegetable origin.

Any water which is turbid, or contains an excess of mineral matters, or gives decided indications of the presence of nitrites, nitrates, and ammonia, is not fit for use, at any rate until it is purified, either by filtration or, in the case of a hard water, until it is softened by Clark's process.

All waters subjected to purification should be examined from time to time, to ascertain that the purifying process is carried on efficiently.

Any water which gives indications of having become contaminated with animal or other impurities, and which

has hitherto been good and wholesome, should be entirely disused until the source of contamination has been ascertained and removed.

In the case of any new public supply, the water should not only be usable, but the best which can be procured within the limits of reasonable expenditure. Samples should be collected, and submitted to a thorough quantitative as well as qualitative analysis.

For a concise account of the quantitative as well as qualitative examination of water, the reader is referred to Parkes' *Manual of Practical Hygiene,* or to Wanklyn and Chapman's *Treatise on Water Analysis.*

In Appendix II. will be found a list of tests, etc.

CHAPTER VII.

IMPURE WATER, AND ITS EFFECTS ON PUBLIC HEALTH.

Although impure water has long been recognised as one of the most potent causes of disease, it is only of recent years that minute investigation has succeeded in demonstrating the terrible mortality which it inflicts on all classes of the community. It is true that chemical analysis often fails in detecting the special impurities on which the development of certain diseases depends; it is also true that, even when impurities are detected, it is extremely difficult to estimate their exact etiological value; nevertheless, the broad fact remains, and it is founded on evidence of the most conclusive kind, that a large number of cases of disease are attributable to the use of impure water, and there are good grounds for believing that, as investigations become more frequent and precise, a continually increasing class of such cases will be discovered. It must also be remembered that the effects of impure water, like the effects of impure air, may engender a general impairment of the health, without giving rise to well-pronounced disease.

Water impurities and their effects may be conveniently considered as follows:—Firstly, water rendered impure by an excess of mineral substances; secondly, water rendered impure by the presence of vegetable matter; thirdly, water rendered impure by animal organic matter.

Section I.—Water rendered Impure by an Excess of Mineral Substances.

As all potable waters contain a certain amount of mineral matters, it is extremely difficult to decide the quantities of these ingredients which may be present, either singly or collectively, without producing bad effects. This much, however, may be said, that waters of a moderate amount of hardness, provided that the hardness depends chiefly on the presence of calcium carbonate, are not found to be detrimental to health. A water of 8 or 10 degrees of temporary hardness, equivalent to about as many grains per gallon of total mineral solids, may be pronounced good and wholesome, while one of as many degrees of permanent hardness would prove injurious to many persons. With regard to the wholesomeness of Thames water, with a hardness averaging 15 degrees before boiling and 5 degrees after, the evidence given before the Royal Commission on Water Supply, 1869, is somewhat conflicting; for while Dr. Letheby considered a moderately hard water, such as the Thames water, best suited for drinking purposes and the supply of cities, Dr. Parkes maintained that the amount of hardness should not exceed 10 or 12 degrees if possible. Mr. Simon and Dr. Lyon Playfair, on the other hand, although they did not condemn the London water on account of its hardness, both expressed themselves in favour of a softer water for purposes of health. The inference that may be drawn from this and other evidence would therefore appear to be this, that the total hardness of a water ought not to exceed 15 degrees, nor the permanent hardness 5; or, in other words, that even in a moderately hard water, calcium

carbonate must always greatly exceed the magnesium and calcium sulphates and sodium chloride.

The symptoms referable to an excess of hardness, arising from the presence of earthy salts, are mainly of a dyspeptic nature. According to Dr. Sutherland, the use of the hard waters derived from the red sandstone rocks underlying Liverpool, produced, in many cases, constipation and visceral obstruction, and an excess of calcium and magnesium sulphates (7 to 10 grains per gallon) has been known to produce diarrhœa.

The special disease, however, which, more than any other, seems intimately connected with the mineral ingredients of water, is goïtre. In Nottingham, where the disease prevails to a certain extent, the common people attribute it to the hardness of the water; and in other parts of England, such as Yorkshire, Derbyshire, Hampshire, and Sussex, it is found to prevail only in those districts where the magnesian limestone formation abounds. According to Dr. Coindet of Geneva, the disease is speedily produced in persons drinking the hard pump water in the lower streets of that town, while in other parts of Switzerland the use of spring water has been followed by the production or augmentation of the disease in a few days. In India, again, the researches, more especially of Dr. M'Clellan, show very conclusively that it is found to prevail only where the magnesian limestone formation prevails. Whether lime and magnesian salts, or ferrum sulphide, as has been suggested by M. Saint-Lager, be the active agents in producing the disease, has not yet been rendered quite clear; but it appears certain that goïtre is originated by water-impurities, and that these are of an inorganic and not organic nature. According to Johnston,

the prisoners in Durham jail were at one time affected with swellings of the neck, and on analysis the water-supply was found to contain 77 grains of lime and magnesian salts per gallon. The swellings disappeared when a purer water was obtained. (*Parkes.*)

The effects of minute traces of metallic compounds in drinking water are as yet comparatively unknown. It is quite possible that the sanitary condition of a district may in a great measure depend on impurities of this description, and, as Mr. Wanklyn suggests, that the salutary effect of "change of air" may be partly due to change in the minute metallic impurity in the water of the parts of the country which are visited.

Of the metallic ingredients, the effects of iron and lead have been the most fully ascertained. It would appear that iron, if present in quantities large enough to impart a chalybeate taste to the water, often produces headache, slight dyspepsia, and general *mal-aise,* while impregnation with lead from leaden cisterns or pipes has frequently been followed by symptoms of lead-poisoning. In the case of the ex-royal family of France, many of whom suffered when at Claremont from this species of water-contamination, the amount did not exceed one grain per gallon; indeed, from cases which have since occurred, it seems probable that the habitual use of water containing from one-tenth to one-twentieth of a grain per gallon may be attended with danger. In his investigations with regard to the Devonshire colic, which formerly prevailed to a great extent, Sir George Baker found that eighteen bottles of cider which he examined contained $4\frac{1}{2}$ grains of lead, or a quarter of a grain to each bottle. The impregnation arose from lead being employed in the construction of the cider troughs. With

regard to the minor effects of lead-poisoning, Dr. B. W. Richardson remarks that "contamination of water, both hard and soft, impure and pure, by lead, is, in all parts of the kingdom and under every variety of circumstances, the cause or source of various obscure diseases of man (and also, doubtless, of the lower animals), of the nature specially of dyspepsia and colic. This proposition was abundantly proved by cases of minor diseases induced by lead-contamination of various of the hard or impure waters of London."

Arsenic, copper, or mercury, are only found in the drinking waters of this country in injurious quantities when streams are polluted by the washings from mines or chemical works.

Section II.—Water rendered impure by Vegetable Matter.

Vegetable matter may be present in water either in suspension or in solution. In peaty water, which is characterised by its brownish tint, the dissolved impurities sometimes do not exceed two grains per gallon. In the absence of a purer supply, a water of this description cannot be pronounced objectionable, provided that it is not stored in leaden cisterns, and that the supply is constant. If stored in open-air ponds or reservoirs, it is improved by oxidation and light; and it is further improved by filtration through gravel and sand.

Water containing a considerable amount of vegetable matter, partly in suspension and partly in solution, is decidedly unwholesome. It has been known to produce violent outbreaks of diarrhœa, and, since the days of Hippocrates downwards, it has been popularly acknowledged to be productive of ague and other malarious

ailments. In this country there are several instances on record, that ague has been much lessened in small communities by using well instead of surface water; and there are good grounds for believing that, apart from the influences attaching to improved drainage, the great decline of this disease throughout many parts of England where it formerly prevailed, is in some measure due to the use of purer water. (*Parkes.*)

Section III.—Water rendered impure by Animal Organic Matter.

From a sanitary point of view, this is by far the most important class of water impurities. The presence of putrescent animal matter, whether it has percolated through the soil from cesspools or other filth-accumulations into wells, or whether it has been discharged from open sewers into streams and rivers, converts drinking water into a dangerous poison fraught with disease and death. It is true that to a certain extent the process of filtration through a porous soil tends to render less hurtful the sewage which dribbles into a well, but after a time this purifying power is lost, the soil becomes sodden, and the sewage enters unchanged. It is also true that, given a sufficiently large stream, a sufficient length of course, and a sufficient length of time, the greater portion of the sewage discharged into a river will become converted into harmless products by oxidation. Yet neither process can be trusted, however complete it may appear to be. There is always danger lurking in a water which is known to be contaminated with animal matter, and more especially when such matter is partly composed of the evacuations of patients suffering from certain specific diseases, such as cholera

or enteric fever. The germs of disease, which may be communicated in this way, have a tenacity of life or chemico-physical power altogether beyond our knowledge.

Leaving out of consideration the question whether animal organic matter in suspension or in solution is the more injurious to health, it would appear that it is the quality rather than the quantity which determines the danger. As already stated, a trace of fæcal matter, especially when undergoing active chemical change, may render a public well poisonous, while a stream of sewer-gas may contaminate the contents of a cistern, and be the means of prostrating a whole household.

The principal diseases which have been proved to be produced by this class of water impurities are, cholera, enteric fever, dysentery, and diarrhœa.

1. *Cholera.*—Although much had been previously written with regard to the etiology and spread of cholera, it was not generally surmised that the disease could be propagated by a polluted water-supply until the late Dr. Snow published the results of his researches in 1849. At first Dr. Snow's views were rejected by some, or questioned by others, but in 1854 there occurred a violent outbreak of cholera in the parish of St. James, Westminster, the causes of which were inquired into by a committee of medical men, whose report fully substantiated Dr. Snow's conclusions. Between the 31st August and the 8th September of that year, as many as 486 fatal cases occurred within an area bounded by a circle whose radius scarcely exceeded 200 yards. On inquiring into the local peculiarities of the epidemic, Dr. Snow found that the sufferers had been in the habit of drinking the water supplied by a

pump-well in Broad Street, which had a great reputation for freshness and sweetness. An analysis of the water proved that it was highly charged with animal impurities, and, at Dr. Snow's earnest solicitation, the handle of the pump was removed by order of the vestry on September 8th, to prevent further use of the water. After this the disease gradually subsided, and ultimately disappeared. It was made manifest, by a subsequent examination, that the sewage of a neighbouring house had leaked into the well, and it was further ascertained that the evacuations of a patient residing in the house, and who was suffering from diarrhœa, or actual cholera, must have mingled with the sewage immediately before the occurrence of the general outbreak. No evidence could well be more convincing that, in this instance at least, the choleraic poison had been conveyed by the drinking water.

Amongst other remarkable outbreaks which go to prove that this mode of cholera propagation is not at all uncommon, may be mentioned the following:—In the autumn of 1865, a gentleman and his wife, from the village of Theydon-Bois in Essex, had been lodging at Weymouth for two or three weeks, and returned home towards the end of September. On their way home they passed through Dorchester, where the gentleman was seized with diarrhœa, vomiting, and cramps, which continued more or less during the next day, and the day following, when they reached Theydon-Bois. During the journey the wife also began to complain of abdominal pain, which was followed by diarrhœa and eventually by cholera, from which she died. A few days after their return, the disease rapidly attacked other members of the household, so that, "within a fort-

night, in that one little circle, eleven persons had been seized with cholera—mother, father, grandmother, two daughters, son, doctor, serving-lad, servant-maid, labourer, and country-woman; and of these eleven only three survived—the son, a daughter, and the serving-lad. Later, in the country-woman's family, there was another fatal case. It cannot well be doubted," continues Mr. Simon, "but that the exciting cause of this succession of events was, in some way or other, the return of the parents from Weymouth, of the father with the remains of choleraic diarrhœa still on him, of the mother with apparently the beginnings of the same complaint. But this is only part of the case, and the remainder teaches an impressive lesson. All drinking water of the house came from a well beneath the floor of the scullery, and into that well there was habitual soakage from the water-closet." (*Eighth Report of the Medical Officer of the Privy Council.*)

In addition to Mr. Simon's report on the cholera epidemics of London in 1848-49 and 1853-54, in which there is sufficient evidence to show that the prevalency of the disease in certain districts was almost entirely determined by the degree of impurity of the water-supply, the conclusions, more especially of Dr. Farr and Mr. Radcliffe, with regard to the localisation and distribution of the epidemic of 1866, are, if possible, more confirmatory still. Thus, Dr. Farr, in his evidence before the Royal Commission on Water Supply in 1869, states that "in all the districts supplied by the Grand Junction, the West Middlesex, and the Chelsea Waterworks Companies, the mortality was about 3 in 10,000; in those supplied by the Southwark and Lambeth Companies, which were formerly so

heavily visited, it was about 6 in 10,000; and in those supplied by the New River Company, about 8 in 10,000; while in those supplied by the East London Company, from the old Ford Reservoirs, it was 79 in 10,000." In effect, the area of explosion was found to be limited to the district supplied by the East London Water Company, and not only so, but Mr. Radcliffe's investigations proved that the water delivered from the Old Ford covered reservoirs had been polluted with water from the filthy uncovered reservoirs, and that these latter had, in all probability, been contaminated with soakage from the river Lea, which received the evacuations of the first two patients who died of epidemic cholera in the eastern districts.

With regard to Scotland, the evidence of Dr. Stevenson Macadam, as to the influence of impure water on the spread of cholera, is also very conclusive. In a report read before the members of the British Associa- in 1867, he showed very clearly that the ravages of the disease were coincident in time and place with the use of water from impure wells, and that in all cases the abatement of the outbreak followed the introduction of a pure and fresh supply.

Without quoting further evidence, it is sufficient to state that the weighty authority of Dr. Parkes strongly confirms this view of choleraic contagion; and indeed the opinions of Professor von Pettenkofer, though at first sight they appear to be antagonistic to the theory, do in reality support it. For, while he considers that the propagation of cholera is due to a fermentation of the rice-water stools, he also maintains that this ferment can only act, and the contagion be generated, under certain local conditions—namely when there is a damp

porous subsoil to receive the ejecta. Although Pettenkofer believes that the air is the sole channel by which the cholera miasm, thus generated in the soil, is spread, there is no doubt that the bearing of the geological influence amounts only to this,—that where populations are living on a damp open subsoil, with no artificial water-supply nor any efficient system of drainage, there the drinking water, as well as the local atmosphere, is almost certain to be largely polluted by those fæcal impurities amid which the diarrhœal contagia are peculiarly apt to multiply. (*Simon.*)

Whether cholera can be produced by animal organic matters not of a specific nature, is still an open question. Very probably the effect of constantly drinking a certain amount of these impurities produces a lowered state of the system and a tendency to diarrhœa, so that, when the cholera poison is abroad in the atmosphere, it finds its victims in largest numbers amongst those who partake of an impure water-supply. This much, however, appears certain, that whenever cholera evacuations make their way into the drinking water, we may expect to find the disease burst forth with the greatest virulence and fatality amongst those who use the water, and that indeed the endemic area will approximate with remarkable closeness to the limits of the district which it supplies.

2. *Enteric Fever.*—The remarks which have just been made with regard to the influence which impure water exerts on the spread of cholera, apply with still greater force to the etiology of enteric fever. For, although there are still some who do not believe in the communicability of the disease, there is a constantly accumulating amount of evidence which goes to prove

not only that the poison of the fever may be conveyed through the agency of water from the sick to the healthy, but that this is the most common mode of propagation. Sir W. Jenner, than whom no higher authority could well be quoted, in commenting on this point, says,—"The spread of typhoid fever is, if possible, less disputable than the spread of cholera by the same means. Solitary cases, outbreaks confined to single houses, to small villages, and to parts of large towns—cases isolated, it seems, from all sources of fallacy—and epidemics affecting the inhabitants of large though limited localities, have all united to support by their testimony the truth of the opinion that the admixture of a trace of fæcal matter, but especially the bowel excreta of typhoid fever, with the water supplied for drinking purposes, is the most efficient cause of the spread of the disease, and that the diffusion of the disease, in any given locality, is limited, or otherwise, and just in proportion as the dwellers of that locality derive their supply of drinking water from polluted sources.

According to Dr. William Budd it also appears to be highly probable that when the poison is conveyed by water, infection is much more certain than when it is disseminated by the air; and in support of this statement he instances an outbreak which occurred in Cowbridge in Wales in 1853, where, out of some 90 or 100 persons who went to a ball, fully one-third were shortly afterwards laid up with the fever. Although the water was not examined, there was satisfactory reason to believe that it was polluted.

Since that date numerous other local outbreaks have been carefully investigated, and some with so much precision and completeness of detail that they are noticed

here rather as examples of the painstaking and systematic way in which such inquiries should be conducted, than as proving this mode of propagation of enteric fever :—

(1.) In the spring of 1867, Dr. Thorne, one of the Health Inspectors of the Privy Council, was ordered to proceed to Winterton in Lincolnshire, to inquire into the causes of the excessive mortality from enteric fever which had prevailed more or less during the previous two years in different parts of the town, but had latterly assumed alarming proportions. The small town numbered about 1800 inhabitants, of whom about nine-tenths consisted of the labouring classes, living for the most part in well-built cottages and earning good wages. Absolute poverty was little known amongst them, intemperance was rare, and only in two instances was there any overcrowding. Moreover, the situation of the town was healthy, inasmuch as it was built on a gentle slope facilitating drainage, and the subsoil was open and porous, consisting of a stratum of oolitic limestone covered by a light marly soil. Yet, with all these advantages, the number of deaths in 1865 amounted to 51, and in 1866 to 44, and of these more than a third had died of enteric fever. At the date of Dr. Thorne's visit 55 cases were under treatment, and already 6 deaths had occurred since the beginning of the year. The cause of all this sickness and mortality is best given in Dr. Thorne's own words :—

"The epidemic prevalence of fever in Winterton is undoubtedly to be ascribed to the disgraceful state of the privies, cesspools, ashpits, and wells. With the exception of about six houses, where water-closets have been constructed, all the cottages are provided with

privies, which are generally built of brick, and have an aperture at the side or back, through which they can be cleaned out. This aperture I found open in almost all instances, and the result of this is that the contents of at least half the privies in the town run out into the gardens, soak into the earth, and penetrate in many instances into the wells, besides producing the most offensive odour. In addition to this many of the tenants either throw their refuse and slops, including urine, into the yards outside their doors, or else they improvise a receptacle by digging in the ground close to the aperture in the privy wall. The fæcal matter pours into it, and they thus add to their previous list of nuisances that of an open cesspool. In some instances ashpits have been built, but these are uncovered, and since urine and the bowel discharges of the typhoid patients are thrown into them, in addition to other refuse, they are but little better than open privies. All these sources of fæcal fermentation are situated, as a rule, close to the houses, and in some instances within a few feet of the back doors, and just under the windows. The wells are also in their immediate neighbourhood, and many of the inhabitants informed me that their water was so bad that they had been compelled to discontinue drinking it. In one instance I found the space between two pigstyes entirely occupied by a well 3 feet in diameter. Fever is present in the house to which this well is attached, but since the occupants do not use it, the necessarily contaminated condition of the water cannot be considered to bear upon the disease. Given the existence of typhoid fever in a town, it is hardly possible to conceive of conditions more favourable for its spread than those existing in Winterton."

Then follow details, and amongst them these :—

Behind a group of four cottages there was a small open court common to them all, and in this court a well to supply the drinking water. Within a circuit of 14 feet round the well, Dr. Thorne found a choked-up drain; an ashpit, on which the fever evacuations were thrown; two pigstyes; three privies, nearly filled with night-soil; and an open cesspool, into which one of the privies emptied itself. In three of the cottages where the epidemic had been so rife, the inmates used the water from this well; while those living in the fourth, and who drew their water from a neighbour's well, had always enjoyed good health. On examination the water was found to be of a light brown colour and disagreeable taste, and to yield a considerable deposit after standing for some time, which contained a large quantity of organic matter, infusoria, and other animalculæ. (*Tenth Report of the Medical Officer of the Privy Council.*)

(2.) In the autumn of the same year (1867), a severe epidemic of enteric fever broke out in Guildford. Dr. Buchanan who was the Government Inspector on this occasion, found that during the first twenty-eight days of August, 10 cases of the disease had occurred in different parts of the town; when suddenly, within the next thirty-three days, the number rose to about 250. As the epidemic was almost exclusively confined to a part of the town which corresponded with a particular section of the public water-supply, suspicions were aroused that this had become polluted; and on further investigation it was ascertained that on a particular day, about 10 days before the outbreak, the houses in that part of the town had been *exceptionally* supplied with

water from a certain high-standing reservoir which had previously been filled from a new well. This well was sunk through a porous stratum of chalk, and in close proximity to it were various sewers, one of which was afterwards found to be leaking in several places. There was no doubt, therefore, that sewage had oozed through the chalk into the well, and had caused the epidemic. An analysis of a sample of the water was subsequently made by the late Professor Miller, the results of which gave unmistakable evidence of previous sewage contamination. (*Tenth Report of the Medical Officer of the Privy Council.*)

(3.) The account of the epidemic at Terling in Essex by Dr. Thorne is especially valuable as showing the effect of a sudden rise of the ground-water level in a village situated on a porous subsoil, obtaining its water-supply from shallow wells, and allowing its excrementitious filth to accumulate in badly constructed privies and manure heaps, or to lie indiscriminately in scattered masses on the surface of the ground. Out of a population of 900, about one-third of the number were attacked with enteric fever within a period of two months, and 41 had died. Some ten days before the outbreak, and after a period of prolonged drought, a sudden great rise in the water-level of the wells was observed to follow a heavy fall of rain and snow; in other words, the shallow unprotected wells sunk in the porous gravel had become converted into so many receptacles for the washings of the filth-sodden soil, and hence the epidemic. (*Tenth Report of the Medical Officer of the Privy Council.*)

(4.) Although in these three epidemics there was no direct evidence to show that the outbreak depended,

in the first instance, on the presence of the enteric poison in the sewage which contaminated the water, it is nevertheless noteworthy that cases of the fever were more or less common in the several localities previous to the outbreak. In the following two instances, however, investigated by Dr. C. Albutt of Leeds, and reported by him in the *British Medical Journal*, the evidence is beyond doubt, not only that the poison found its way into the drinking water, but that this was the sole cause of the outbreak. In the one case, which occurred at Ackworth, near Pontefract, in March 1870, it was found that the area of the outbreak was limited to a part of the village and school supplied by water from a certain well. The water, on analysis, gave rather more than 5 grains of organic matter, 6 of sodium chloride, and an unusual amount of nitrates and nitrites; and it was further ascertained that though it must have been contaminated with sewage previous to the outbreak, no cases of the disease appeared until a patient was brought home to the village who was suffering from the fever. The discharges of this patient were thrown on loose ground, which drained into the water of the well.

The other instance occurred at Bramham College, Yorkshire, in March 1869. It appears that two of the pupils were laid up with enteric fever in February, but circumstances showed that they must have contracted the disease before their arrival at Bramham. Towards the end of March, 19 fresh cases occurred, and all of them about the same time. This sudden outbreak clearly pointed to some common cause which must have been in operation, and it was then discovered that the well used to supply drinking water was con-

taminated by soakage from a soft-water tank, into which sewage matter had passed from a broken water-closet pipe. The discharges of the first two patients had also passed into this tank, and had doubtless been the cause of the outbreak. Another important fact connected with this outbreak was the distribution of the disease amongst the pupils, it being confined to those who drank water, while those who drank beer escaped. As the same water was used for cooking purposes, it would thus appear that the poison must have been destroyed by boiling.

3. *Dysentery.*—The instances of outbreaks of this disease which have been traced to the presence of animal impurities in drinking water are so numerous, especially in Eastern countries, that the mere mention of the fact will suffice.

4. *Diarrhœa.*—In addition to outbreaks occasioned by direct sewage contamination, there are several recorded cases of the following description:—In the Salford Jail there was a sudden outbreak of diarrhœa of a choleraic type, which affected 57 per cent of the prisoners, while of the officers and their families, who were distributed throughout the building, not one was attacked. The food of the prisoners was examined and found to be good; it was evident also that the air did not contain the cause of the disease, for both classes were under the same conditions in that respect; suspicion was therefore directed to the drinking water. It was then discovered that, though the water supplying all parts of the prison was derived from the same source, there was one cistern for the use of the officers, and another covered cistern to supply the prisoners, and that the untrapped overflow-pipe of the latter communicated with an open sewer. On the day of the outbreak the water from this cistern was observed to be coloured, and

to taste unpleasantly. It had obviously absorbed sewer-gas, which had ascended through the overflow-pipe; and that this had been the real cause of the disease was confirmed by the fact that the outbreak disappeared almost as rapidly as it commenced, when the cistern was emptied and the pipe efficiently trapped. (*Second Report of the Medical Officer of the Privy Council.*)

Outbreaks of diarrhœa are also very liable to appear when well-water becomes contaminated with the animal organic matter derived from grave-yards.

Concluding Remarks.—Although an attempt has thus been made to classify roughly the hurtful impurities of water, and the diseases which they may severally produce, it need hardly be said that in the great majority of instances of faulty sanitation connected with water-supply, there is often a combination of impurities and of diseases both. For example, the analysis of waters which have proved to be decidedly injurious shows that in general the impurities are numerous; and, on the other hand, not one but several diseases may be either directly produced or indirectly influenced by them. And this difficulty of apportionating to special impurities their special effects is frequently increased by the presence of other causes of disease. Thus, the water may not only be polluted, but the supply may be scanty; and thereby give rise to great want of cleanliness of the person, of clothes, of cooking utensils, and of the general surroundings; while overcrowding, defective sewage-removal, badly ventilated drains, and other causes of disease, may also co-operate in seriously affecting the health of a community and largely increasing the death-rate. But the purport of these remarks will be best illustrated by quoting a few of the many similar *précis* given in Mr. Simon's Reports:—

Cases inquired about, and dates when each came before the Department.	Ground of Inquiry.	Names of Inspector, and *Précis* of Report.
Chesham (Oct. 1871).	Reported prevalence of fever, diarrhœa, and measles.	Mr. Power. Severe epidemic of typhus. Much overcrowding and filth-pollution of water. Systems of drainage and excrement-disposal required.
Dudley (May 1871).	Regis.-General's return. Prevalence of fever.	Dr. Thorne. Endemic scarlatina, typhus, enteric fever, and diarrhœa. Defective and insufficient sewerage. Polluted water in private wells. Inefficient excrement and refuse disposal. Ill-constructed fittings, and overcrowded houses. Nuisances from pigstyes. No means for isolating contagious fevers.
Great Grimsby (Nov. 1871).	Rg.-Gen.'s return. Information of epidemics of scarlatina and smallpox. Prevalence of diarrhœa and fevers.	Dr. Home. Polluted water; inefficient system of excrement and refuse removal; incomplete drainage and sewerage nuisances. Houses unfit for habitation. Inadequate sanitary supervision.
Kingsthorpe (1870).	Regis.-General's return. Prevalence of scarlatina, enteric fever and diarrhœa.	Dr. Buchanan. Want of drainage. Water polluted. Accumulations of excrement and filth. No means of isolation or disinfection.
Newton Valence (June 1871).	Information as to prevalence of diphtheria.	Dr. Home. Ill-constructed and unventilated cottages. Insufficient privy accommodation. Bad water. Nuisances.
Perry Street (Aug. 1871.)	Complaint of sanitary defects, and of prevalence of zymotic diseases.	Dr. Thorne. Wells polluted by soakings from privies and cesspools. No proper system of excrement-disposal. No system of drainage or sewerage. No sanitary action by vestry.

(*First Report of the Local Government Board.*)

According to Dr. Stevenson Macadam, it is highly probable that other diseases, such as, ulcerated throat, low fever, and erysipelas, have occasionally a water origin; and although the evidence which he brings forward cannot be said to be conclusive, it is nevertheless very circumstantial. It would also appear that the prevalence of calculous disease and gravel bears a close relation to the amount of lime and magnesian salts contained in the drinking water of certain districts. This disputed subject has lately been investigated by Dr. Murray of Newcastle-upon-Tyne (*Brit. Med. Journal,* September 28, 1872); and his statements, together with the cases which he adduces, are certainly strongly corroborative of this view. Finally, it has to be noted that several of the *entozoa* find their way into the body by the agency of drinking water, as, for instance, the *Bothriocephalus latus* and the *Ascaris lumbricoides.*

CHAPTER VIII.

DWELLINGS.

The vast importance attaching to the sanitary conditions of dwellings has already been frequently alluded to in previous chapters. Diseases arising from unhealthy site, from insufficient ventilation or overcrowding, from tainted or stinted water-supply, from defective drainage, or from accumulations of filth, are all of them associated with habitations which are faulty in their situation, construction, or management.

Section I.—Site.

In choosing a site, special attention should be paid to the nature of the soil and the general conformation of the ground. The soil, if not dry, should be drained, and all hollows wherein water is likely to lodge should be avoided. Where possible, the aspect should be open and cheerful, so that an abundance of light and a free movement of air can be obtained.

In towns, a great evil sometimes arises from building on rubbish containing vegetable matter which has been used to fill up the excavations made in brickmaking. Thus Mr. Crossby reports that the high rate of mortality in Leicester during the autumnal months was chiefly due to an annual visitation of infantile diarrhœa which prevailed in parts of the town built on such refuse; and he distinctly attributes the disease

to this cause. Further, the evidence of Drs. Parkes and Sanderson, in their valuable report on the sanitary condition of Liverpool, though negative as regards the effects of cinder-refuse on the health of the occupants of houses built upon it, clearly points to the conclusion that such a soil is objectionable, at any rate when first laid down. With regard to this point, they advised the Town Council to adopt the following rules:—

"1. No excavation should be used for the reception of cinder-refuse unless it is efficiently drained. This appears to us to be of especial importance in relation to the filling up of brickfields. It is well known that the whole of the surface of clay is never removed, and there is always sufficient to form an impermeable basin, in which, in the absence of drainage, water constantly collects. We hold it to be of the greatest importance, for the rapid decomposition of whatever offensive material may exist in the 'cinder,' that it should be able to become dry. The only way in which this can be promoted or secured is by efficient subsoil drainage.

"2. As the vegetable and animal matter contained in the cinder-refuse decays and disappears in about three years, and is virtually innocuous before that time, we recommend that places filled up with cinder-refuse shall not be built upon for at least two years from the date of last deposit."

They also advised that road-scrapings should not be mixed with the cinder-refuse, and that the scavenging department should be more careful with regard to the selection of material.

Section II.—Structural Arrangements.

In building on a site which has already been occu-

pied, great care should be taken to make a thorough examination of the ground, so that no cesspits, rubble drains, or old wells, may escape notice. Every old drain should be taken up, all removable filth cleared away, and every pit thoroughly cleaned out and filled in with concrete.

Unless absolutely necessary, no drain should traverse the basement of a house; and when it is necessary, as when houses are joined together in streets or squares, every such drain should be made absolutely air and water-tight. Pipes of glazed earthenware are best suited for the purpose. They should be laid on a bed of concrete made with ground lime or cement, securely jointed, and covered with concrete. They should also be provided with full means of ventilation at either side of the basement. When they pass through foundation walls it is advisable that relieving arches should be turned over them, because it often happens that they become broken by settlements, or during the consequent underpinning. Outside the building the pipes should be laid in a water-tight trench of clay puddle or concrete, and should lie their full diameters below the subsoil of the basement, in order that the lowest parts of the house may be efficiently drained.

To facilitate inspection, the outside track should be provided, at suitable intervals, with access pipes. These are of various patterns, but all of them permit an easy opening into the drain, so that deposits or obstructions can be readily removed. To prevent the formation of such deposits, all house drains should be regularly flushed. (For further particulars, see Chapter on Removal of Sewage.)

Where a cesspool is required to receive the sewage

of a house, it should be situated at a safe distance from the building, made perfectly water-tight, and be abundantly ventilated. The plan of construction should be on the liquid-manure tank principle, the walls being of brick-work set in cement, surrounded by a clay puddle, and lined inside with a coating of cement. Both roof and bottom should be arched, the roof provided with a manhole, and the bottom built with a fall towards one end, where a pump could be fixed. The depth should not exceed 6 or 7 feet, otherwise the increased hydrostatic pressure would necessitate expensive walling. To separate the solids from the liquids, a galvanised iron wire diaphragm or grating should divide the tank into two parts. All cesspools should be regularly cleaned out at least once a month.

If the water-supply is to be derived from a well, the well and cesspool should be widely separated. In case of accidental leakage, it is also necessary that the well should not be near the house drains. To exclude subsoil water, the upper part of a well should be made water-tight, and the mouth should be protected against the entrance of surface water.

After having secured dryness and healthiness of subsoil, the next point of importance which has to be kept in view is the isolation of the area upon which the proposed dwelling is to be erected from the subsoil, and this can be effected in the cheapest and best way by using concrete. In order to prevent damp from rising into the walls, a damp-proof course should overlay the whole of the foundations. Two or three courses of slate laid in the best cement will answer the purpose, or, if external symmetry in the damp-proof course be made a desideratum, tiles made of highly vitrified stone-

ware should be employed. When there is a basement storey, it should be isolated from the ground by an open space. The entrance of underground damp may also be prevented by constructing what are called dry areas; that is, by leaving a space between the main wall and a thin outer wall which reaches to the ground level, the two being joined together here and there by stretching bricks.

As much of the dampness in walls is due to driving wet, well-planned houses are now often built with hollow walls, in which case ties or bonding bricks must be laid in at regular intervals, to render the strength and stability of the twin walls equivalent to a strong single wall. With single walls, built of soft porous material, the effects of driving wet may be obviated by slating or tiling them, or by applying to the outer surface one or other of the several patent waterproof compositions which are well recommended.

Perforated bricks should be introduced at suitable distances in the outer walls, to admit air to the joists and beneath the flooring.

One of the gravest faults in the construction of even the better class of houses in the present day is the little attention which is paid to the position and arrangements of water-closets. They are too frequently situated in out-of-the-way corners, where only borrowed light can be obtained, and efficient ventilation is impossible. The best position is in an isolated block, built tower-fashion and abutting against the outer wall of the house, with a closet on each floor and the supply cistern on the top. There should be an anteroom or passage between each closet and the house, large enough to admit of sufficient cross ventilation by means of open windows or windows

provided with ventilating panes. A double set of doors would be required,—one leading into the house and the other cutting off the passage from the closet. The closet-seat should face a window in the outer wall, so that abundance of light may be secured for inspection with regard to cleanliness, and direct draught from the window be avoided. The window should extend up to the ceiling, and have double sashes. The closet may be permanently ventilated by keeping the top sash drawn down, or by air-bricks inserted immediately beneath the ceiling. In smaller sized houses the closet may be simply projected from the building, with the seat facing the door, and with two opposite windows reaching to the ceiling between the seat and door. Cross ventilation and sufficient light would thus be obtained, without the interposition of an anteroom.

There are so many kinds of closets, well arranged in all their details, that it is difficult to say which of them are most to be recommended. There are others, again, such as the round hopper closet-pan fixed into an ordinary sigmoidal bend, which cannot be sufficiently condemned, unless worked by a very high pressure of water;—they are constantly getting foul, and it is seldom that the whole of the excreta are removed. Generally speaking, those closets are the best which provide for good flushing and rapid and complete removal of the excreta, without permitting reflux of foul air. The pan should be roomy and made of white glazed earthenware, the machinery should work easily and not be apt to get out of gear, and the seat should be so framed as to come asunder readily to permit of inspection. Amongst closets which have been found to work satisfactorily may be mentioned the "Holborn Closet" and

"Universal Closet," both manufactured by Mr. Finch of the Holborn Sanitary Works; the "Patent Valve-Closet and Trap" of Mr. Jennings; the "Elastic Valve-Closet;" and "Underhay's Regulator Valve-Closet."

As soil-pipes communicate directly with the drains, they should be carried up to the highest part of the roof, and be of the same diameter throughout. Efficient ventilation of the drains is in this way secured at a most important point, and the pipe from the closet trap can be connected with the soil-pipe without interfering with the upward current of sewer-air. If the soil-pipe cannot be carried straight up to the top of the house, the bends or angles should be made as obtuse as possible, and in any case it should not be plastered or built into the wall, but left free for inspection throughout its whole track. It is obvious that, were this plan universally adopted, there could be no pressure of sewer-gas against the closet trap, and therefore little or no risk of its entering into the house by this channel.

It has been urged, by way of objection against this plan, that, where houses are closely packed together, and are of different elevations, the sewer-gases discharged from the pipes of the lower houses would find their way into the higher, and thus become not only a nuisance but a source of danger. With ample sewer-ventilation, however, the objection does not hold good, because the sewer-air is so diluted as to be inoffensive and comparatively pure; besides, in cases where it is proved to be offensive, some such mutual arrangements as are adopted with regard to offensive chimneys would meet the difficulty.

With regard to all other pipes, whether waste-water pipes, sink-pipes, or pipes from lavatories, it should

be laid down as a rule that none of them should lead directly into either the soil-pipe or drain. They should be carried outside the house to within 12 or 18 inches from the ground, and deliver on to the grating of a yard or gulley trap. Such a trap might be ventilated by the rain-water pipe when the rain-water is allowed to flow into the drain, or through a charcoal tray. But although the sewer-gases are in this way prevented from entering the house, it is still necessary that the sink and other pipes should be trapped. Scullery and sink pipes, for example, will require article-intercepting traps, and pipes to lavatories or baths must be provided with syphon traps to prevent the ingress of cold air.

All traps on house-drains should be ventilated either by pipes carried to the roof or parapet of the house, or by means of charcoal trays. Unless protected in some such way, they are comparatively useless.

Details concerning the ventilation and warming of a house have already been given in Chapter IV., and the only points which need be repeated are—the importance of constructing a separate extraction flue for each room in the chimney-stack, the desirability of inserting ventilating fire-places, and the great advantage of securing that the products of gas-combustion be conveyed by special channels into the outer air.

It is needless to say that the rooms in a well-constructed and healthy house should be spacious, airy, and light. The windows should reach to within a short distance of the ceiling, and should always be made to open. It is preferable to have them glazed with plate glass, to economise heat. No single bedroom should be of less dimensions than 1000 cubic feet, nor should any bedstead be fixed in a recess.

Section III.—Dwellings for the Poorer Classes.

In constructing buildings for the poorer classes, the great difficulty, encountered at the very outset, consists in providing the necessary accommodation with the requisite sanitary arrangements at a cost which will allow of a sufficiently low rental. In towns the original cost is greatly increased by the high price of land, but even in country places, where a site can be procured at a cheap rate, the cost for the erection of a cottage of the humblest pretensions will entail a rental which many a labouring man can barely meet. Where the ground rental is low, the cheapest and most commodious form of labourer's cottage is one without any upper storey. Thus, according to Mr. Allen, in his Manual on Cottage Building, a cottage consisting of a living-room for general every-day uses, a bedroom for the labourer and his wife, a bedroom for boys, a bedroom for girls, a small wash-house, a store room, and closet, could be built for £100, provided all the rooms are on the ground-floor, and that two such cottages be ranged side by side, so as to be spanned by the same roof, and contained within four walls, forming a simple parallelogram. The row of cottages proposed by Dr. Hunter in the Seventh Report of the Medical Officer to the Privy Council, provided for a front and back kitchen in each cottage, and two bedrooms over head. The kitchens were to be paved with brick or tile, "the front about 11 feet by 11, by 6 feet 8 high; the back about 11 by 8 feet 6. Ceiling would be unnecessary. There should be five doors only, the closet under the stairs one, each bedroom one, and two house-doors. There should be four sliding windows, a grate with an oven, a boiler in the back

kitchen, a little fire-place in one bedroom, and a Welsh slate roof, the bedrooms being ceiled.

"Such houses might be supplied for £50, or £1500 for the thirty."

In this plan, and in fact in almost all plans for cottage construction, the cubic space allowance is very limited, so that overcrowding, to a greater or less extent, is sure to prevail at times. Cottages which are scarcely roomy enough for a married couple and two or three children become occupied by much larger families, or the family increases in number year after year, while the bedroom accommodation remains the same. The initial space, therefore, should be ample enough to meet the requirements of, at any rate, moderate family increase; and when a number of such cottages are built in the same locality, they should be of different sizes, to suit small and large families alike.

In large towns the house-accommodation for the labouring classes must necessarily be supplied in a great measure by what are called tenements. The following is a copy of the bye-laws sanctioned by the Treasury in 1867 for this class of dwellings, built from loans under the Labouring Classes Dwellings Act 1866:—

"Separate water-closet accommodation to be provided for each tenement, or else, where water-closet accommodation is to be used in common by the occupants of two or more tenements, separate accommodation must be provided for each sex. Such accommodation may be either water-closet, earth-closet, or privy.

"Each tenement to have a dust-bin, or the use of a dust-bin common to several buildings.

"Each tenement to be well lighted by external windows made to open.

" Each tenement to have ready access to water.

" Where several tenements in one building, proper ventilation to be provided for the passages, staircases, etc.

" The drains to be well constructed.

" Parties to whom moneys to be advanced to enter into covenants with the Public Works Loan Commissioners,—That where there are several tenements in one building, they

" (*a*) Will cause the passages, staircases, etc., to be kept clean.

" (*b*) Will cause the water-closets, etc., to be kept in good order.

" (*c*) Will cause the dust-bins to be emptied at intervals of seven days.

" (*d*) Will take precautions against any interruptions in the supply of water.

" (*e*) Will keep the windows in good order and repair, and the chimneys swept.

" (*f*) Will keep the drains in proper order.

" (*g*) Will allow inspection by Commissioners of Works, to see that the above covenants are observed.

" Number of cubic feet in each room of the several classes of tenements for which money has been authorised to be advanced :"—

	One room of cubic feet.	One room of cubic feet.	One room of cubic feet.	One room of cubic feet.	One room of cubic feet.
Class I. of two rooms	715	1219	—	—	—
Do.	816	994	—	—	—
Do.	995	1020	—	—	—
Class II. of four rooms	960	960	960	960	—
Class III. of five rooms	372	675	1056	1656	1232
Do.	446	459	459	781	1468

Of equal importance with the construction of dwellings for the labouring classes is the far more difficult problem of repairing and improving the unhealthy abodes which, in town and country village alike, increase the annual rate of mortality to an extent that can hardly be estimated. It is true that the law already prohibits the inhabitation of the worst class of dwellings, such as damp, dark, underground cellars; but there are other dwellings, so numerous that their immediate demolition would deprive a large proportion of the lower classes of shelter, which no alterations or improvements can render healthy. They are either situated in narrow, dingy alleys, or huddled together in close courts, so as to be practically unventilable, or their internal condition and constructural faults are so grave as to be beyond remedy. Nor are these the only sanitary defects connected with them which have to be condemned. It is in these very dwellings that the filth and poisonous effluvium due to overcrowding are constantly accumulating, and where the germs of disease find a fitting soil for their development. The departmental reports of the Privy Council afford numerous instances of such a state of things, and notably those of Drs. Hunter, Stephens, and Buchannan.

In country districts, where there is far less excuse for the existence of these evils, it has been found that in reality they are almost as glaring and wide-spread as in towns. The elaborate report of Dr. Hunter on the State of the Dwellings of Rural Labourers (see *Seventh Report of Medical Officer of Privy Council*) may be quoted in proof of this statement. In all, 5375 cottages were reported upon. Of these, 2195 contained only one bedroom; 2930 contained two; and only 250

more than two. The number of persons resident in them, including adults and children, was 24,770, giving an average of 4·6 persons to a house, or 2·8 to a bedroom. In the single-bedroomed houses, the average number sleeping in the bedroom was 4, 2·2 of whom were adults and 1·8 children. The average cubic space for sleeping accommodation was estimated at 156 feet per head. The rickety state of the great majority of the hovels permitted a freer interchange of air than in the new cottages, so that, although the cubic space per head in the latter was somewhat larger, the contained air was generally more impure. Indeed, many of the bedrooms were so much exposed to the weather, that cases of sickness, when they did occur, had to be treated in the kitchen. But the wretched sanitary condition of the dwellings was even a less evil than their numerical insufficiency. It was found that many landlords pulled down the cots on their estates when they fell into decay, without providing others, and thus forced the labourers to find house-room in already overcrowded hamlets. As a consequence, this huddling together of human beings not only presented numerous *foci* for the development of disease, but rendered the limitation of any contagious diseases which were introduced an almost hopeless task. That such a state of things continues to exist in most rural districts, the late revelations connected with the strike of agricultural labourers shows but too clearly. The same sacrifice of life from overcrowding, the same absence or even the barest essentials of comfort, and the same outrages to common decency, appear to be as rife now as they were at the time of Dr. Hunter's inquiry.

Hitherto sanitary legislation has achieved comparatively little in abating the enormous evils arising from unhealthy dwellings, overcrowding, and filth accumulation; but it is to be hoped that, as the requirements of public health become more widely appreciated, and the Sanitary Acts more rigidly enforced, they will speedily be greatly mitigated, if they cannot be entirely removed.

In large towns the difficulty of dealing with what is called "surface-crowding" must necessarily, for many years to come, throw great obstacles in the way of reaping to the full extent the advantages to be gained from lessening the indoor-crowding. In the worst parts of Liverpool, according to Drs. Parkes and Sanderson, nearly 1000 persons are huddled together in one acre of ground, and in other towns, such as Glasgow and Greenock, the number per acre in some districts is quite as great. It is clear that no improvement in the dwellings, nor any increase in the amount of cubic space per head, will render the ventilation as satisfactory as it should be, when so many houses are packed together in such a limited space. Demolition of old houses, the displacement of the population into blocks of model dwellings, or into houses put into serviceable repair, and the opening of new streets, are all necessary. The recommendations of Drs. Parkes and Sanderson, in their Sanitary Report on Liverpool concerning this point, are so generally applicable to almost all large towns that they may be fitly quoted here:—

"It is impossible for the Corporation to provide houses for its poor citizens. That would be simply offering a premium to pauperism. But it appears to us that great aid would be given to those who can pro-

vide houses, by two measures which may be properly carried out by the municipal authorities.

"The first step for the improvement of the wretched houses of Liverpool must be the bringing of pure air into the crowded quarters. This can only be done by opening wide and straight streets in such directions and to such an extent as may be determined after consideration of all the circumstances. If gradually carried out, this would displace the population from some part of the worst quarters, and would prepare the way for the improvement of houses that remain.

"The second step would be an adjunct to this. As the object is to spread the population over a wider area, some of the workmen will be at a greater distance from their work than at present. This must be met by facilitating means of transport, by which the difficulties of distance are removed. The conditions of urban and suburban life have been totally altered, in the lifetime of the present generation, by the use of railways, tramways, river and road steamers. Advantage should be taken of these agencies for sanitary work.

"If improved means of transport can be combined with the formation of new streets, so as to let the workman be practically as near his work as he was previously, the inconvenience inflicted on those who are obliged to move would be moderate and transient, while the benefit to all would be great and permanent.

"With regard to the expense of such improvements (which, of course, would be gradually carried out), we may safely say that no expense can be so heavy as that produced by a constant yearly mortality so great as that which prevails in Liverpool. It is certain that sickness

is the most costly of all things, and on this ground alone we advocate this proposal. But we would advocate it on higher grounds than its ultimate money advantage. It is incumbent on its authorities to remove from Liverpool the great opprobrium of being the most unhealthy town in England; and surely some sacrifice, if needed, will be made to secure to the poorer citizens, as far as public action can do it, the inestimable blessing of health.

"In recommending the construction of new streets, we are well aware that the powers actually vested in the Corporation are inadequate for the purpose. It would be necessary to obtain powers from Parliament, in the same manner as for any other public object. It should be distinctly understood that, although the alterations we contemplate would no doubt be advantageous in many other respects, the end for which we recommend them is exclusively for the improvement of the public health; and the Corporation, in disposing of the land purchased, should be guided entirely by sanitary considerations. We would recommend, for example, that any land which the Corporation might have to dispose of should not be used for the erection of lofty buildings, such as large warehouses, which, by obstructing the free circulation of air, would rather hinder than promote one of the main objects in view; but exclusively for the construction of dwelling-houses for the working classes; and the conditions of disposal should be of such a nature as to ensure—

"(1.) That the houses should be constructed under the immediate supervision of the officers of the Corporation, as regards drainage, ventilation, and general plan;

"(2.) That they should be maintained in sanitary repair, under strict regulations.

"By this scheme, and by persevering with the measures in force, a great improvement would in a few years take place in the ventilation of the houses in the crowded quarters; and we are confident that there would be a commensurate and material improvement in the health of those living in them."

But there is another question connected with displacement of the population which seriously affects the poorer classes in almost all our large towns. Many extensive undertakings, such as the construction of railways and new streets, while they act beneficially in making wide clearances in the crowded districts, only tend to increase the overcrowding in neighbouring parts. The families that are thus rendered homeless by the demolition of their dwellings seek the nearest shelter, rents are raised in consequence of the increased demand for accommodation, and such as cannot afford to expend more than they did previously must be contented with homes even less healthy than those which they have been compelled to leave. As a compensating measure, the running of working men's trains morning and evening, between the suburbs and the town stations, although it is a step in the right direction, does not by any means meet the difficulty. Larger measures are undoubtedly required, and the more thoughtful amongst sanitary reformers are agreed in maintaining that no parliamentary powers, permitting the demolition of numerous dwellings in populous districts, should be granted unless the companies or corporations applying for these powers provide commensurate and improved accommodation elsewhere, and within reasonable distances. It is true

that many of the displaced population might not choose to remove to the new dwellings, but they should have the option. Tenants, at all events, would not be wanting, and that there would be no financial loss is clearly proved by the profits gained by private enterprise in building homes for the working-classes, although it must be admitted that numbers of such houses, as they are run up in the present day, can scarcely be pronounced habitable. Urban sanitary authorities have, however, full powers vested in them by the statutes to prevent the erection of dwellings that are unwholesome, and it is their duty to see that the accommodation and structural arrangements are in all cases satisfactory.

Concerning the duties of the medical officer of health with regard to overcrowding and places unfit for habitation, together with the sanitary enactments dealing with the same, see Chapter XIV. and Appendix I.

CHAPTER IX.

HOSPITALS.

In large towns the position of every hospital must primarily depend on the distribution of the population, or part of the population, whose wants it is intended to relieve, and hence the choice with regard to site is often very limited. Apart, however, from this restriction, there are certain considerations which ought always to influence the selection of site. For example, the future hospital should be erected in as airy and open a space as can be obtained, preference being given either to the outskirts of towns or to their largest interior unoccupied spaces. According to the recommendations of the Chirurgical Society of Paris in 1864, a free area of not less than 540 superficial feet should be allowed for each patient. This would give an acre of ground for a hospital containing 80 beds. In this country, on the other hand, an acre for 100 patients has been held to be sufficient. Any defect in salubrity of site must be compensated by increased floor and cubic space.

No doubt, the most healthy site for a hospital is in the open country, with a dry and porous soil, and slightly raised above the plain to facilitate drainage. While shelter from the cold north-easterly winds is desirable, it is an error to build hospitals on the face of a steep slope, or in any situation where there is an impediment to a free circulation of the air. Clayey soil and un-

drained marshy ground should be avoided, nor should houses or clumps of trees be in close proximity to the building.

For hospitals situated in the crowded localities of large towns, convalescent homes in the country, or at the sea-side, are now being provided, and with marked advantage to the patients.

The late discussions on hospitalism, though perhaps somewhat one-sided in giving such prominence to the test of surgical results, have fully established the great hygienic advantages which small cottage hospitals possess over the large palatial buildings that have hitherto found favour with the profession. It is further generally admitted that, when large hospitals are rendered necessary, they should approximate as much as possible to the sanitary conditions which can only be ensured by small detached buildings. The application of this principle has resulted in the construction of hospitals on the pavilion system—a system which accommodates itself to almost any site and to any number of patients.

Section I.—Pavilion Hospitals.

In this description of hospital, each pavilion may be regarded as a separate hospital, and the impurities of every single ward are cut off from the other wards. The pavilions are united by a corridor for administrative purposes and for convenience, but are so arranged that a free circulation of air can always take place between them. In its simplest form a pavilion would consist of a single ward, with the necessary additions for administration. More frequently, however, it consists of two wards, one above the other, and, in some instances, of

three wards, as in the Marine Hospital at Woolwich. Three-storeyed pavilions are objectionable, because their height necessitates a lofty corridor to unite them, and induces stagnation of the air. With two-storeyed pavilions, on the other hand, the corridor need only be

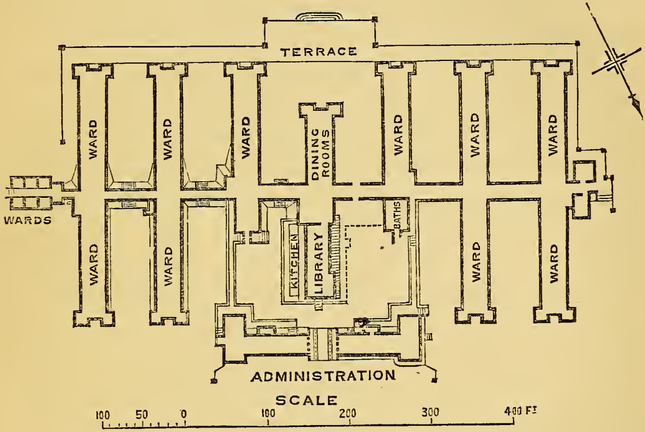


Fig. 8.—GENERAL PLAN OF HERBERT HOSPITAL, WOOLWICH. (From "Construction of Hospitals," by Douglas Galton.)

half the height of the pavilions. In large hospitals, such as the Herbert Hospital, the pavilions may be united in twos, end to end, with the corridor running between them, the staircase being, as it were, strung

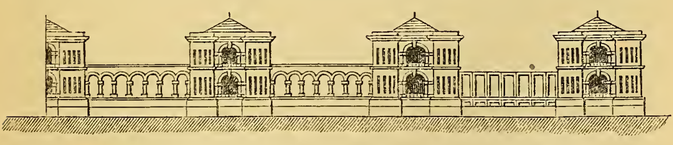


Fig. 9.—Sketch of the end of the southern Pavilions of Herbert Hospital, showing the elevation of the corridor. (After Galton.)

on to the corridor. The distance between the pavilions should be at least twice their height.

The basis or unit of hospital construction is the ward. The conditions which determine the size and form of a ward are the following :—

1. The number of patients which it should contain.

2. The floor and cubic space allowed to each patient.

3. The arrangements for warming, light, ventilation, and nursing.

1. The number of patients in a ward will depend on the size of the hospital, and, occasionally, on the nature of the cases. A cottage hospital, for example, will necessarily consist of small wards, and even in large hospitals small wards are required for isolating very severe or special cases. With these exceptions, however, the number of patients in a ward must depend mainly upon the number which can be efficiently nursed at the smallest cost per head. Miss Nightingale, in the Report on Metropolitan Workhouses, fixes this number at 32. She says, " a head nurse can efficiently supervise, a night nurse can carefully watch, 32 beds in one ward, whereas, with 32 beds in four wards, it is quite impossible." Throughout European hospitals the number varies from 24 to 32.

2. One of the most important questions attaching to hospital construction is the amount of floor and cubic space which should be allowed to each patient, and there is scarcely any question concerning which there has been so much discrepancy of opinion. Thus, Dr. Todd maintained that 500 cubic feet were sufficient; Dr. Burrows, 1000; the Army Sanitary Commission, 1200; and the Committee appointed to consider the cubic space of Metropolitan Workhouses, 850. The recommendations of this Committee further limited the cubic space allowance for dormitories to a minimum of

300 feet, and for wards containing infirm paupers to a minimum of 500 feet per head. There is no doubt, however, that, in consequence of the conflicting evidence on which the Committee had to base its recommendations, the difficulties of efficiently ventilating small spaces without draught were not sufficiently appreciated, but as reference has already been made with regard to this point, it need not be again discussed. Suffice it to say that General Morin, the greatest French authority on ventilation, to whom the disputed subject was submitted, gave it as his opinion that, even for paupers who are not ill, he considered it "necessary not to descend below 880 cubic feet of space, and besides this the condition must be imposed of renewing the air in the proportion of 1060 cubic feet per individual per hour."

That the recommendations of the Committee have failed in securing purity of the air in workhouses, is shown in the reports on night-nursing which appeared in *The Lancet* in 1871. With regard to the Holborn Workhouse, for example, the report states that "there are upwards of 200 sick paupers here, of whom the great majority are unable to leave their beds. There are 240 deaths in the year, or an average of 5 per week. The wards are low, close almost to offensiveness, and overcrowded; although they may be an improvement on the style of thing which was in vogue twenty years ago, they nevertheless cut a sorry figure when compared with even the worst-built of our general hospitals." And again, with regard to the Marylebone Workhouse:— "The amount of cubic space varies from 300 to 1200 feet. In some of the wards the beds absolutely touch, and there is scarcely room to thread one's way between

the rows. The atmosphere in these wards is, as may readily be imagined, anything but nice. It is true, the inmates of them are comparatively healthy, but we should think that the arrangements are well calculated to rob them of what health they have."

For ordinary hospital cases, it is now generally admitted that a cubic space of at least 1200 feet should be allowed per patient, and for cases of infectious disease, or for severe surgical cases, as much as 4000, and it may be doubted if this be sufficient at all times.

On the superficial area per bed will depend the distance between the beds, the facilities for nursing, and the conveniences for ward administration. This, like the cubic space, has been variously estimated. Thus, in St. George's Hospital it is only 69 square feet; in St. Bartholomew's it is 79; in the Herbert Hospital, 99; in the Netley Hospital, 103; in Guy's, 138; and in the new St. Thomas's Hospital, 112. For all nursing purposes, Miss Nightingale maintains that at least 90 square feet should be allowed per bed, and this amount, according to Captain Galton, should be accepted as a minimum. Where medical schools are attached to hospitals, an extra allowance must be allotted for the requirements of clinical teaching. The space must also be greatly increased in fever or lying-in wards. The height of an average-sized ward should be 13 or 14 feet.

3. For providing sufficient light and for maintaining purity of the air, much depends on the width of the ward. Experience has shown that this should not be less than 24 feet, and not more than 30 or 35. In the new Leeds Hospital, it is 27 feet 6 inches; in the new St. Thomas's, 28 feet; and in the Herbert Hospital, 26.

The ventilation of each ward should be entirely independent of the others, and to effect this cross-ventilation by means of open windows, aided by Sheringham valves, extraction-flues, and ventilating fire-places, is deemed to be the most efficient. In the summer months, when fires are not required, the windows should always be kept more or less open, except during rough blustering weather.

When a window is allowed for each bed, which is sometimes the case, the wall-space between the windows should be six or eight inches wider than the bed. In the pavilion system, however, an allowance of one window for every two beds is generally considered sufficient, the beds being arranged in pairs between the windows, and separated from each other by a distance of at least three feet. The windows should reach from within two feet or two feet six inches from the floor to within one foot from the ceiling. The space between the end wall and the first window on either side of the ward should be four feet six inches, and the space between the adjacent windows, nine feet, the windows themselves being four feet six inches wide. An end window to a long ward adds greatly to its cheerfulness, and aids materially in the ventilation of the ward. The ordinary sash window, made to open at top and bottom, is perhaps preferable to any other kind. To economise heat, plate-glass should be used instead of ordinary glass.

In addition to means of ventilation provided by windows, there should be a fresh-air inlet, furnished with a Sheringham valve, placed near the ceiling and between each window. When the fire-places are situated in the external walls, two or three fresh-air

inlets may be provided at equal distances along the centre of the floor, and communicating by means of transverse flues beneath the flooring with the external air. Such inlets are so far removed from the beds that the currents entering through them are not felt by the patients when in bed, and they could be closed if deemed necessary during the day-time. The gratings covering them should be capable of easy removal, so that the flues may be cleaned out regularly.

The extraction-flues should be situated, if possible, on the same side of the ward as the fire-places, and should be carried above the roof and louvered. When not contiguous with a chimney, they should be provided with gas-jets to aid their extractive power. If the fire-places are situated in the centre of the ward, the extraction-flues should be placed in the opposite corners. The inlets to extraction-flues ought to be near the ceiling, but not in close proximity to the fresh-air inlets.

The fire-places best suited for infirmary wards are the ventilating stoves already described in the Chapter on Ventilation. But in addition to these, or in place of them, the fresh air might also be heated by hot-water pipes, coiled in boxes below each bed, as recommended by Dr. Parkes, or the pipes might pass along behind the skirting, the skirting being perforated or supplied with gratings opposite each bed, for the admission of the heated air.

Every gas-jet in a ward should be furnished with a bottomless lantern communicating with an extraction-tube to carry off the products of combustion, or Rickett's ventilating globe lights should be used. (For particulars with regard to ventilation, see Chapter on that subject.)

The furniture in a ward ought always to be reduced to a minimum, and should never be cumbrous or bulky. Iron bedsteads are to be preferred to wooden ones, and thin horse-hair mattresses, placed on springs, to thick flock or woollen mattresses. All bedsteads should be ranged at a short distance from the walls. Coverlets and blankets should be white or light-coloured, to show dirt, and ought to be frequently aired.

The other points of sanitary importance connected with a ward are its offices, and the materials employed in construction.

Ward-offices are required for facilitating nursing, and for the direct use of the sick. Thus every ward should have attached to it, at the end nearest the door, a scullery and a nurse's room, and, at the farther end, a water-closet and ablution-room. The nurse's room should be light and airy, and large enough to be used as a bedroom. It should also be provided with a window, looking into the ward, for purposes of inspection. The scullery should be situated opposite the nurse's room, and ought to be fitted with a small range, for warming drinks, preparing fomentations, etc.; a sink with hot and cold water laid on; and shelves and racks for dishes. It should be large enough for the assistant nurses to take their meals in.

The water-closet and ablution-room should be situated, one at either farther corner of the ward, and both should be completely cut off by means of swing doors and a lobby supplied with cross-ventilation from the ward. The water-closet apartment ought to contain one closet for every 10 beds, or 3 closets for 32, and should also be supplied with a sink and a urinal. Instead of a handle and plug for turning on the water

for flushing, it is preferable to have a self-acting water-supply connected with the door, because some patients are careless, and others are too feeble to raise the handle.

The ablution-room should contain a plunge-bath with hot and cold water laid on, a shower-bath over-hanging the broad end of the plunge-bath, and a lavatory table fitted with basins, and also supplied with hot and cold water. There should likewise be room enough to contain a portable bath on wheels, a hip-bath, and a foot-bath for the use of patients more or less bed-ridden. The pipes leading from the sink and lavatory table should not be boxed in, because the spaces thus enclosed become receptacles for dirt.

The supply of water should be ample, and the drainage and sewerage perfect. All closet and sink pipes should be ventilated and placed against outside walls. The various fittings should be of a light colour, to show dirt, and thus ensure thorough cleanliness. The walls of closets and ablution-rooms should be lined with Parian cement, glazed tiles, or enamelled slate.

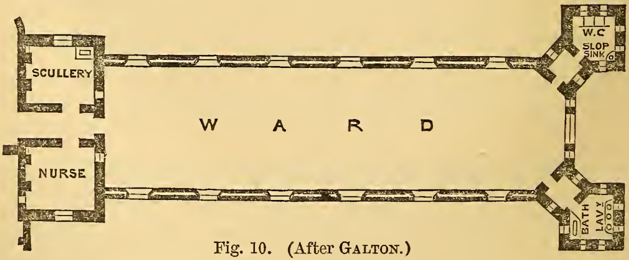


Fig. 10. (After Galton.)

With regard to the materials of ward construction, it is now strongly recommended that floors should be made of hard wood, such as oak, laid on concrete and well jointed; that the walls should be lined with Parian

cement, or well plastered, periodically cleaned, and whitewashed or painted; and that the ceilings should be plastered and whitewashed, or painted a light colour. Floors of upper wards ought to be non-conductive of sound.

A ward thus constructed and arranged is in itself a small hospital, and the aggregation of ward-units will depend on the number of patients to be accommodated.

In an average-sized hospital, the administrative buildings occupy considerable space, and may be variously distributed. All of them, however, must be made entirely subservient to the requirements of the sick, and should not interfere with the ventilation of the wards. Usually the administrative buildings are as follows:—

Kitchen, provision-stores, and stores for bedding and linen. These should be central.

Apartments for house-surgeon, matron, and servants; consulting room, waiting room, surgery, drug-store, and operating room; all of them more or less central.

Laundry, mortuary, *post-mortem* room, disinfecting room. These should all be detached from the building.

The night-nurses should have well-ventilated bedrooms at a distance from the wards, with all the necessary appliances for ablution, etc.

The staircases for patients should be broad and easy, and should be cut off from the connecting corridors by swing-doors. The corridors themselves should be as low as possible, well lighted, warmed, and ventilated.

According to Captain Galton, the administrative buildings take up about half the cubic space of the whole hospital. As very good examples of the pavilion

form of hospital on the small scale, he instances the Royal Hants County Hospital at Winchester, the Buckinghamshire County Hospital at Aylesbury, and the New Hospital at Swansea.

With regard to the cost of pavilion hospitals, Captain Galton is of opinion that, with care and attention to economy in the design, a hospital for in-patients only, and built on a favourable site, should not cost more than from £90 to £120 per bed. The Leeds Hospital, which accommodates 350 patients, cost £197 per bed; the Royal Hants Hospital, with 108 beds, and including accommodation for out-patients, cost £229;

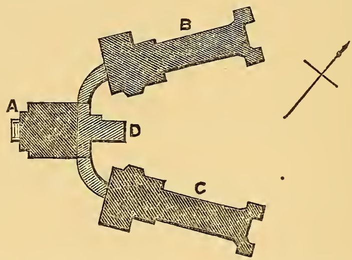


Fig. 11.—GENERAL PLAN OF SWANSEA NEW HOSPITAL.
A, Administration; B, Men's Wards; C, Women's Wards and Out-patients; D, Operating Room and Eye Ward. (After GALTON.)

and the Swansea Hospital, also including an outside-patient department, cost £142 per bed.

Day-wards, exercising grounds, and flower or winter gardens, are great additions to the sanitary advantages supplied by a well-constructed hospital. In summer, all the patients who are able to move about, and, indeed, most of those who are bed-ridden, should be allowed to remain during some part of every warm day in the open air. The flat roofs of the corridors, protected by awnings, could be utilised for the bed-ridden patients of the

upper wards, while the corridors themselves might be appropriated by the same class of patients belonging to the lower wards. With very little extra expense the corridors could be converted into winter gardens during the colder months of the year, and might be occupied by patients in the day-time, without interfering with any of the administrative arrangements.

A new mode of hospital construction has been lately proposed by Mr. Greenway of Plymouth. In this plan each patient occupies a separate glass compartment, which is so ventilated that the vitiated air is directly removed, without much chance of its mingling with the air in the ward. The compartments are ranged in a double row along the centre of the ward, and separated from the side-walls by a corridor on either side. As the ceilings, as well as the partitions, are proposed to be of glass, there is little doubt that great cleanliness could be ensured, but the risk of constant breakages, and the difficulties in the way of efficient nursing, it is to be feared, would more than counterbalance any other advantages which this plan possesses. The cost per bed has been estimated at £150.

Section II.—Cottage Hospitals.

The cottage hospital system, originated by Mr. Napper of Cranleigh, is based on the principles of providing hospital accommodation for the sick poor of rural districts, with as much of the surroundings of home as possible; of permitting equality of privilege to subscribers in recommending patients, the patients themselves paying a certain sum weekly, according to their means; and of allowing any medical man practising in

the district the use of the hospital for deserving cases under his care. The model cottage hospital should not have more than six beds, and must be under the management of one medical man as director, the other medical men in the district holding office as honorary medical officers. The annual cost of the establishment is defrayed chiefly by voluntary contributions, and partly by the weekly payments of the patients. These weekly payments, as already stated, are regulated by the means of the patient, and vary from 2s. 6d., when the Union has to help, to 5s. or 8s., when the patient has been earning fair wages, or belongs to a club. All fees allowed by the Union for accidents or operations are paid to the Union medical officer, in the same way as if he had attended the patient at his own home. Every subscriber, no matter what the amount of his subscription, should have equal privileges in recommending cases, and will generally be able to state what amount the patient whom he recommends can afford to contribute weekly. Cases of accident and emergency are admitted without order, but otherwise a recommendation from a subscriber must be procured, and this should in all instances be accompanied by a certificate from one of the medical staff, to the effect that the case is one deserving and fit for admission. Only those are admitted who cannot be efficiently treated at their own homes, while cases of infectious or incurable disease are excluded.

Experience has proved that in rural districts a cottage hospital of six beds will suffice for a population of 6000. The initial outlay will of course depend on whether a cottage which has already been built can be procured, and if so, what alterations will be necessary

to convert it into a hospital. If the hospital has to be built, the amount required may be estimated at £500, or about £90 per bed. In converting a cottage, which has already been occupied, into a hospital, the walls should be thoroughly cleaned, scraped, and afterwards replastered and washed with caustic lime. Attention must also be paid to the sanitary surroundings of the building.

The cost of furnishing a cottage hospital for six beds will amount to about £100, and the necessary surgical instruments to about £50. The maintenance per patient weekly costs from 8s. to 10s., so that the hospital, when once started and properly furnished, will require for its support an annual income of at least £120, about £25 or £30 of which will be subscribed by patients.

Although the architectural arrangements may admit of many variations, the plan best suited for a cottage hospital of six beds should provide for a nurse's room, a three-bedded male ward, a two-bedded female ward, a single-bedded ward, which can be used as an operation-room, a kitchen, which may also be used as a day-ward, a scullery, and a small mortuary. All the rooms should, if possible, be on the ground-floor, so that good roof ventilation and ample cubic space may be secured. Part of the roof should overhang, so as to form a sort of verandah for the use of patients. It need scarcely be added that a tasteful arrangement of flowers and shrubs in the space immediately surrounding the hospital will add greatly to its cheerfulness.

The nursing, cooking, and cleaning, can generally be efficiently attended to by one woman. As the duties are therefore of a somewhat more arduous nature than those of a nurse in a general hospital, they cannot be

discharged by lady-nurses or sisters. Indeed, it is found that a homely woman from the neighbourhood, trained at the hospital or elsewhere, gets on much better with the patients than the professed trained nurse. She should be able to read and write well, and must be steady, honest, attentive, and cleanly.

If a cesspool is used for the receptacle of excreta, it should be at a safe distance from the building, and constructed as described in the Chapter on Dwellings. Where no water is laid on, the dry-earth system is found to answer very well. (See *Handy Book of Cottage Hospitals* by Dr. Sweete.)

SECTION III.—HOSPITALS FOR CASES OF INFECTIOUS DISEASE.

By the 37th section of the Sanitary Act, 1866, power is given to the sanitary authorities of any town or district to provide, for the use of the inhabitants, "hospitals or temporary places for the reception of the sick;" and when such provision has been made, any justice may order the removal to the hospital of any person suffering from a dangerous infectious disease who is without proper lodging, or lodged in a room containing more than one family, or is on board ship.

In a Memorandum of the Privy Council printed in the Appendix to the First Report of the Local Government Board, it is recommended, as a condition of the first importance, that the accommodation for isolating cases of infectious disease shall be ready beforehand, and further that it shall be sufficient for the treatment of different infectious diseases separately. The amount of accommodation required will of course vary for

different places. As regards villages, for example, it is recommended that "each village ought to have the means of accommodating instantly, or at a few hours' notice, say four cases of infectious disease, in at least two separate rooms, without requiring their removal to a distance. A decent four-room or six-room cottage, at the disposal of the authority, would answer the purpose. Or permanent arrangement might be made beforehand with trustworthy cottage-holders not having children, to receive and nurse, in case of need, patients requiring such accommodation. Two small adjacent villages (if under the same sanitary authority) might often be regarded as one."

If further accommodation be at any time required, neighbouring cottages should be hired, or tents or huts may be erected on adjacent ground.

For towns of any importance the hospital provision ought to consist of a permanent building containing at least four wards in two separated pairs, each pair to receive patients of both sexes suffering from one contagious disease. The building should be larger than the average necessities of the place require, so that temporary extensions may be wanted less frequently when infectious disease has become epidemic. In case, however, such temporary extensions should be required at any time, the administrative offices ought to be made somewhat in excess of the wants of the permanent wards, and sufficient free space should be reserved around the building.

The minimum floor-space recommended is 144 square feet, and the minimum cubic space 2000 feet. The arrangements for ventilation, heating, removal of excreta, disinfection, and the maintenance of the strictest

cleanliness, ought to be of the most approved description.

Temporary extension of the accommodation may be provided in the summer and autumn by tents, and in the winter and spring by wooden huts. The tents recommended are, the regulation bell-tent of the War Department, 513 cubic feet space, and the regulation hospital marquee of 3000 cubic feet space. The former should not contain more than one patient, nor the latter more than three. The ground on which they are pitched should be kept dry by means of trenches around and between them; the floors should be boarded; the approaches paved or boarded; and the tents themselves should be everywhere distant from each other at least a diameter and a half. All slops and refuse matter should be carefully removed.

With regard to huts, "dryness of site is, as in the case of tents, of the first importance. Each hut should be trenched round. Its floor should be raised a foot or a foot and a half from the earth, so as to permit the free under-passage of air; but care must be taken to prevent the lodgment of moisture or impurities beneath the floor. A distance not less than three times the height of a hut should intervene between any two huts, and each hut should be so placed as not to interfere with free circulation of air round other huts. In huts, as in permanent buildings, for the treatment of infectious diseases, not less than 2000 feet cubic space, with 144 square feet of floor, should be given to each patient. The ventilation of huts, also, is of equal importance with that of permanent hospital buildings. It is best secured by the combination of side-windows with roof-opening, the latter protected from rain, and running the

whole length of the ridge of the roof. The windows, capable of being opened top and bottom, should not be fewer than one to each pair of beds, or in large huts, one to each bed, nor should be of less size than the sash-window in common use for houses. The ventilating opening beneath the ridge may have flaps, movable from within the tent by ropes and pulleys, so that the opening to windward can be closed, if necessary, in high winds. Doubled-walled wood huts may have additional ventilation by the admission of air beneath this outer and inner wall, and its passage into the interior of the hut through openings with movable covers at the top of the inner lining. The roof should be covered with waterproof felt; the edges of the felt fastened down by strips of wood, not by nails. The hut should be warmed by open fire-places, fixed in brick-stove stacks placed in the centre of the floor, the flue being carried through the roof."

In places where no sewerage-system exists the excreta may be removed by the pail or dry-earth system, but in either case disinfectants should be used, and outside doors or flaps should be provided in the closet-blocks to permit the removal of the excreta directly from the closets and not through the wards.

The following are ground-plans of a hospital hut for eight patients of each sex, having the same infectious disease (fig. 12), and of an extension of hut-hospitals where plenty of ground is available (fig. 13). Both plans are copied from the Memorandum of the Medical Department of the Local Government Board already referred to.

The majority of temporary hospitals erected by the London vestries have been made of corrugated iron

lined with match-wood. In the Hampstead hospital the interval between the wood and iron is filled up with felt, a plan which adds greatly to the warmth of the hospital and prevents draughts.

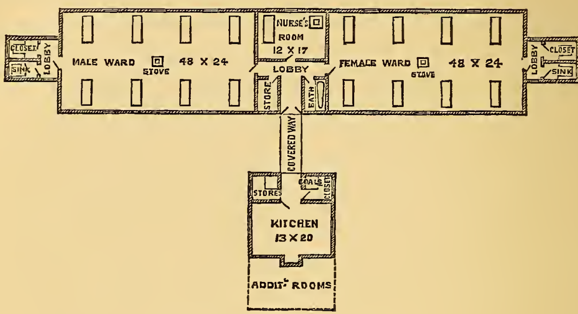


Fig. 12.

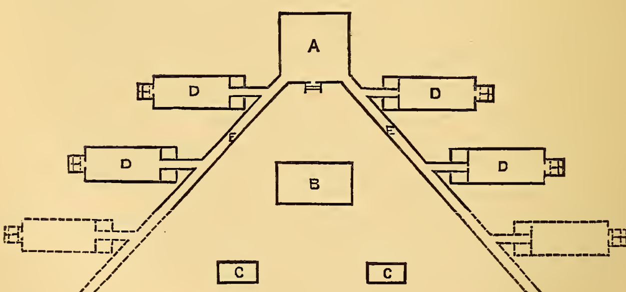


Fig. 13.—A, Administrative Buildings (Kitchen, Stores, Offices, Nurses' Bedrooms, etc.); B, Laundry, etc.; C, Disinfection, Dead-house, etc.; D, Huts for 10 patients each, with Scullery and Bath-room at end, and Closet and Sink at other end of each; E, Open Corridors. The dotted lines show direction of farther extension.

At seaport towns it is proposed to use hospital-ships of the "Dreadnought" type, but any hull of an old vessel, capable of floating and large enough, would suffice. Wooden huts erected on the upper deck would supply

the ward accommodation, while the body of the vessel could be utilised for the administrative department. The "Dreadnought" is fitted with a Warren's cooking-stove, which is well adapted for the requirements of any temporary hospital, inasmuch as it is complete in itself and very economical. Hospital-ships would prove of immense value in the event of cholera again visiting this country.

CHAPTER X.

REMOVAL OF SEWAGE.

The term sewage may be conveniently used as indicating the excrementitious matter thrown off by the bowels and kidneys, and, indirectly, the refuse, whether solid or liquid, which is constantly accumulating in inhabited places, and requires to be constantly removed if cleanliness and health are to be maintained. A consideration of this subject will therefore have reference not only to the different methods of excretal removal, but also to scavenging.

Section I.—Middens, Ashpits, and Cesspools.

In thinly-populated districts the disposal of the excreta and house-refuse is accompanied with little risk, provided they are not allowed to accumulate in close proximity to a house or near a well. The open midden, ashpit, or cesspool, under these circumstances, cannot be pronounced very objectionable from a sanitary point of view, because they can be cleaned out periodically without creating a nuisance, and any neglect in keeping them in order is seldom attended with serious consequences. In towns, however, the case is very different. These filth-accumulations, when no other system of removal is followed, are of necessity in close

proximity to the houses, and the effluvia arising from decomposition may, and often do, become so intensified as to pollute the surrounding atmosphere to an extent which is seriously detrimental to health. (See Chapter on Air.) But in addition to this danger, there is the other, and perhaps greater danger, of water-contamination. The fluid contents of the midden or cesspool may drain into the surrounding soil, so that eventually it becomes excrement-sodden, or it may find its way into the neighbouring well. Hence, in many instances, the inhabitants may be said to live in an atmosphere charged with the mephitic gases given off by the decomposition of their own excrement, and to drink a water tainted by the foul liquid which oozes from the excretal mass. No wonder then that special diseases are engendered, that the general health of the community is lowered, and that poverty, with all its attendant evils, overtakes the disabled among the working-classes.

Formerly such a state of things was the rule, and not the exception, in towns, as well as in less densely populated parts. The midden or cesspool consisted of a hole dug in the ground, with no attempt at preventing percolation, or the escape of effluvia into the surrounding air. But, even in the present day, the reports of the Health Inspectors of the Privy Council show that in many places there has been little or no improvement in this respect. Thus, to select a few out of the numerous reports summarised in the First Report of the Local Government Board, the following may be given:—

Cases inquired about, and date when each first came before the Department.	Ground of Inquiry.	Name of Inspector, and Extracts from *Précis* of Report.
Astley Bridge, Lancashire (October 1871).	Prevalence of diarrhœa.	Dr. Ballard. Want of sanitary supervision. Accumulations of excrement and house filth. Pollution of stream by sewage.
Barnet (April 1871).	Fever at New Barnet, and alleged impure water-supply.	Mr. Radcliffe. Nuisances from cesspools and foul ditches. Water good.
Basingstoke (September 1871).	Memorial from inhabitants as to sanitary state of town.	Dr. Ballard. Enteric fever. Polluted wells. Air and soil befouled with excrement from cesspits.
Biggleswade (January 1871).	Prevalence of scarlatina, measles, and typhoid fever.	Dr. Corfield. General pollution of earth, air, and water, by excrement. Want of privy accommodation.

These extracts are quoted *seriatim* as they are given in the report, and may be taken as representing the sanitary condition of the great majority of the other 55 places which were examined and reported on during 1871. But even this gives a very meagre idea of the extent to which this frightful neglect with regard to nuisance-removal prevails throughout the country; for, in addition to the above, 86 other cases of local epidemics, either present or threatening, were brought under the notice of the Health Department of the Local Government Board, into which no personal inquiry could be made, on account of the numerical inadequacy of the inspectorial staff. The same defects would

doubtless have been found to exist in the great majority of these localities, and it is not too much to assume that they prevailed to a greater or less extent in many other places, although the mortuary returns did not direct special attention to them.

Excrement and refuse lying about the narrow streets and back courts, excrement and urine soaking into the soil and oozing into underground cellars and wells, excrement accumulating in enormous cesspools or open ditches, no provision for excrement-removal;—such phrases as these are repeated so frequently in the reports of the Health Inspectors as to make them appear stereotyped and sensational. And yet they are only bare statements with regard to numerous instances of the grossest sanitary neglect. In many towns, such as Northampton, Guildford, Leicester, and Bridport, built upon porous strata, it was found that the contents of the cesspools drained so freely into the ground, that their removal was either not required at all, or at very rare intervals. In others, again, such as Steyning, the cesspools drained into open ditches, or, as at Penzance, overflowed, after a heavy shower, into the gutters.

Merely covering the midden and cesspool, therefore, by no means lessens the dangers attaching to them. One special requisite is that they be lined with cement, or made otherwise water-tight. In Manchester the midden-pits are lined with Rochdale flags embedded in mortar, and have the bottom sloping to an outlet opening into the drain. The ashes and house refuse are introduced either through an opening in the front of the privy seat, by lifting the privy seat when hinged, or through a shoot protected by a gird which sifts them, so that the cinders are retained, to be again used as

fuel. Ventilation of the pits is secured by providing ventilating flues, which are carried up the walls of the houses to three feet above the eaves, while removal of the contents is effected through holes closed by ledged doors, which open into the passage running behind the row of houses.

With regard to the different plans of the midden-system found in use amongst the poorer classes, Dr. Buchanan and Mr. Radcliffe (see *Twelfth Report of Medical Officer to Privy Council*) give the following summary:—

"(*a*) The midden-system of old type (in all the old parts of almost all towns).

"(*b*) Middens of large size, and permitting much accumulation, but compulsorily supplied with some means of keeping the contents dry (covers, drains, or both), and for preventing leakage into the earth (Preston, Leeds, Birmingham).

"(*c*) The same (though smaller), with the addition of special constructions aiming at the effectual covering of excrement by ashes.

"By sloping bottom (Nottingham, Stamford).

"By hinged seats or steps (Manchester, Salford).

"By ashpit and shoot (Manchester).

"(*d*) The same arrangement, with the midden reduced to a mere space under the seat (Hull)."

In the Hull system the ashes are thrown in through a hole in the seat, and the front board of the seat is movable to enable the scavenger to get at the contents. The slops go into the drains.

Where the midden-system is continued, it is essential that the pit should be small, in order to ensure frequent removal of the contents; that it should be

water-tight, be roofed in, and have a sloping floor; and that it should be well ventilated, and situated at a safe distance from the house. It is not necessary that it be drained, for if the ashes do not keep the excreta dry, the system is a failure. But even when it is carried out with every regard to structural detail and management, the midden-system will always be objectionable, not only on account of the great expense of scavenging, but also because of the annoyance and discomfort necessarily arising from the frequent visitations of the soil-cart.

Particulars with regard to the construction of a cesspool suited for isolated buildings have already been given in the Chapter on Dwelling-houses. In this country, the continuance of the cesspool-system in large towns is condemned, not only on account of the nuisance attending removal, but because the more liquid contents are allowed to drain into the sewers, and are productive of as much pollution in the sewers as water-closets. On the Continent, however, the system is still carried out on a large scale. The *fosses permanentes* of Paris, Brussels, and other continental towns, are huge pits, placed generally under the courtyards. They are lined with cement, so as to render them impervious, and are usually ventilated by shafts rising some feet above the roofs of the houses. The contents are removed three or four times during the course of the year by air-tight carts (*tonneaux*), from which the air is exhausted previous to filling, so that the sewage is forced into them through a hose by atmospheric pressure. The closets in connection with the cesspools are almost invariably in a filthy state, from the habit of standing on the seat, which appears to be prevalent in private houses as well as in public places.

A modification of the *fosse permanente* has been introduced by Captain Liernur, a Dutch engineer, known as Liernur's system. In this system the cesspool consists of an air-tight iron tank, situated under the street, and connected by iron pipes with the closets in the houses. The tank is emptied daily by pneumatic pressure, into closed carts, and the excreta are carried along the pipes into the tank by exhausting the contained air. No water is used in the closets.

Section II.—The Pail or Trough System.

The more common varieties of this system may be enumerated and described as follows :—

1. *Boxes* used either with or without preparation, removed daily, or several times a week. At Leeds, according to the report of Dr. Buchanan and Mr. Radcliffe, they receive the excreta without any preparation; but at Nottingham a little earth or ashes is previously inserted to prevent the contents adhering to the box. The ashes and house-refuse are collected in separate bins.

2. *Tubs*, generally made from disused casks, into which a little fine ash and common salt is sprinkled, with a view of retarding decomposition to a certain extent, and of facilitating the emptying of the contents. This plan is followed at Rochdale. As the tubs are supplied with tight-fitting lids, they are removed without creating much nuisance.

3. *Tubs* prepared on the Goux system, as practised at Salford and other towns. In this system the tubs are lined with some dry absorbent material, such as chaff, straw, refuse, hay, dry ferns, or any kind of animal and

vegetable matter which is useless for other purposes. The patentees direct that these materials are "to be mixed in such proportions as may be most convenient, together with a small percentage of sulphate of iron or sulphate of lime." The materials are pressed close to the bottom and sides of the tub by means of a mould, which is afterwards withdrawn. A separate bin must be used for the ashes and house-refuse; but urine may be emptied into the tub, and is supposed to be absorbed by the lining, the excreta remaining tolerably dry. The tub is removed once or twice a week, according to circumstances.

When these closets are well managed, they are generally clean and inoffensive; but in many cases Dr. Buchanan and Mr. Radcliffe found that the solid excreta were not kept dry, and then the tubs possessed no vantage over unprepared tubs.

The same system has been applied to public urinals, the absorbent material acting as a filter through which the urine passes into a receptacle containing a small quantity of iron sulphate. The urine thus collected is afterwards used along with the contents of the tubs in the preparation of manure.

4. *Pails,* into which ashes as well as excrement are thrown. This system has long been followed in the more crowded parts of Edinburgh, but is objectionable in many respects. The pails are deposited daily in the streets, and the contents carted away by the scavengers.

5. The *Pail* or *Trough-closet* system. This also is in use in Edinburgh and Glasgow, and is adapted to large collections of people. In the pail-closet system, the closets are ranged in double rows and roofed in, with a passage between them for the scavenger. The

seats, and the divisions between them, are made of slate. A pail is placed below each seat, and removed daily. In connection with the privy is a water-tank for cleansing purposes. In the trough-system, the iron trough or latrine has a sloping bottom, and is supplied with a little water to make the contents run easily. These are emptied through a vertical pipe into a closed tank, from which they are removed in closed carts, without, it is said, creating much nuisance. In some of the Glasgow factories there is one such latrine on each of the storeys, and it is used by 180 to 200 persons.

6. In the *Eureka system,* as carried on some time ago at Hyde near Manchester, a box containing some deodorising mixture was placed under the privy-seat. It was allowed to remain there for several days, and when full was closed with a tight-fitting lid previous to its being carted off to the manure manufactory. No slops were allowed to be put into the boxes. The manufactory, however, became such a nuisance that the system was discontinued.

7. *Fosses Mobiles.*—This system is now followed in many continental towns, and is a great improvement on the system of *fosses permanentes.* The *fosse mobile* is a closed tube placed on a stand with wheels, and connected by a descent-pipe with the different closets or *faiences* of a house. When filled it is replaced by another of the same construction. The *abfuhrtonnen* of the Germans are of a similar description, but in many of the larger towns the bucket under the privy-seat is used (Berlin, Leipsic, etc.)

Wherever the pail or trough system is carried on, it is requisite that the pails or boxes should be straight and round, so that they can be easily cleaned. The

material best suited for their construction is galvanised iron, or wood well pitched with tar. The closets or privies in connection with them should also be built of non-absorbent materials, such as slate. Above all, it is essential that the system be under the management and control of the public authorities, to ensure cleanliness of the privies, and regular and efficient removal of the excreta.

SECTION III.—THE DRY METHOD.

1. *Moule's Earth-closet.*—This consists of a wooden box with a receptacle or pail beneath, a reservoir for the dry earth above, and an apparatus for measuring and delivering the requisite quantity of earth, whenever the closet is used. The closet is made self-acting by means of a spring in connection with the seat, or it is worked by a handle as in the ordinary water-closet. It is essential that the earth be previously dried and sifted, that a sufficient quantity be thrown into the pail before the closet is used, and that the same amount be delivered over each particular stool. The quantity requisite for the deodorisation of each stool (inclusive of the urine) is found to be $1\frac{1}{2}$ lb. The slops and the rest of the urine must be removed in some other way.

This system has been introduced, with more or less success, into several public establishments in this country (Broadmoor Lunatic Asylum, the Manx Lunatic Asylum, Isle of Man, the Reading Workhouse, etc.), at the Wimbledon Camp, and several villages throughout the country. Its use in India has been very highly spoken of by Dr. Mouatt, late Inspector of Indian Gaols.

Dr. Buchanan, in Mr. Simon's Report for 1869, makes the following summary with regard to the working of the earth system :—

"(1.) The earth-closet, intelligently managed, furnishes a means of disposing of excrement without nuisance and apparently without detriment to health.

"(2.) In communities the earth-closet system requires to be managed by the authority of the place, and will pay at least the expenses of its management.

"(3.) In the poorer classes of houses, where supervision of any closet arrangements is indispensable, the adoption of the earth system offers special advantages.

"(4.) The earth system of excrement-removal does not supersede the necessity for an independent means of removing slops, rain-water, and soil-water.

"(5.) The limits of application of the earth system in the future cannot be stated. In existing towns, favourably arranged for access to the closets, the system might be at once applied to populations of 10,000 persons.

"(6.) As compared with the water-closet, the earth system has these advantages :—it is cheaper in the original cost, it requires less repair, it is not injured by frost, it is not damaged by improper substances driven down it, and it very greatly reduces the quantity of water required by each household."

The agricultural value of the earth excrement, its facility of transport, and variety of application, are also pointed out.

The disadvantages of the system are,—the difficulties of procuring, drying, and storing the earth, particularly in crowded localities; the special service

and attention which the closets require, the frequent discomfort attending their use when the earth is very dry and powdery, and the inadequacy of the system as a means of removing the whole excreta and slops. "Add to these circumstances the enormous aggravation of all the difficulties of the plan, when not 50 but 50,000 households have to be provided with the necessary appliances, and induced to work them properly, and we can have no hesitation in pronouncing the dry earth system, however suitable for institutions, villages, and camps, where personal or official regulations can be enforced, entirely unfitted to the circumstances of large towns." (*First Report of the Rivers Pollution Commissioners*, 1868.)

When the closets are properly managed, it appears that the fæcal matters are disintegrated, so that after a time no excrement whatever can be detected in the mixture. After keeping and drying, therefore, it may be used several times without losing its deodorising and absorbing properties, but much depends on the quality of the earth used at the outset. The suitability of various soils are given in the following order:—1, rich garden mould; 2, peaty soils; 3, black cotton soils; 4, clays; 5, stiff clayey loams; 6, red ferruginous loams; 7, sandy loams; 8, sands.

For isolated buildings and small country villages, where there is no difficulty in obtaining suitable earth, and afterwards disposing of it, and where the necessary labour and management can be procured, the system, according to Dr. Parkes, is almost perfect.

The closets may either be used as fixtures or as movable commodes, the latter being intended for use in bedrooms, hospital-wards, etc.

2. *Taylor's dry Closet.*—In this closet the fæces and urine are separated by means of a revolving disc, which is worked by a lever in connection with the closet-seat. When the lid of the seat is lifted the disc moves slightly round, and when it is closed a small quantity of ashes, or of ashes mixed with disinfecting powder, is thrown from a hopper upon the soil. The solids are retained on the disc until a complete revolution is made; by which time they are usually almost dry, and are then scraped off by a knife into a receptacle beneath. The whole apparatus is thus made self-acting in connection with the opening and closing of the lid, and each time the closet is used a certain portion of the soil which has been longest exposed on the disc is removed. The urine runs off into a neighbouring drain, ditch, or tank.

The apparatus is more costly than the common earth-closet, and the disc gets very much soiled, and requires to be frequently cleaned;—in other respects the plan has been well spoken of.

3. Various other modifications of the dry method have been tried or proposed, among which may be mentioned the Carbon Disinfecting and Deodorising Closet of Messrs. Weare and Co., in use in several parts of Liverpool; the employment of charcoal from seaweed, and of carbonised excreta instead of earth as proposed by Mr. Stanford; and carbonising the excreta in retorts and using the charcoal thus obtained as a deodoriser for fresh excreta, as proposed by Mr. Hickey. All of them, however, are more or less open to the objections which have been urged against the earth-closet system, and do not meet the requirements of large communities.

SECTION IV.—REMOVAL BY WATER.

This is the only system suited for large towns. The same channels which are required for the removal of the waste water, may also, if properly constructed, be used for the removal of sewage, and not only so, but the waste water can be utilised as a very efficient vehicle for the conveyance of the excreta. In most cases the subsoil water, surface water, and the water used for domestic purposes, are all eventually discharged by the same channels, so that the drainage and sewerage of a town usually form part of the same system.

1. *Drains and Sewers.*—In any system of drainage, whether for towns or country districts, it is necessary that the drainage channels should have sufficient area and declivity to maintain the discharge of the water which they receive at all times, and at its fullest flow. This quantity will of course depend chiefly on the rainfall of the locality to be drained, and upon the amount entering the drains from other sources. Thus, in country districts, the water to be carried off may be partly derived from porous strata, which have their gathering ground beyond the boundary ridges of the drainage-area; and in towns, the water-supply artificially brought in is added to the amount derived from the drainage of the inhabited district. Moreover, as the soil acts as a kind of reservoir, the water does not enter the drains in the open country as rapidly as it falls, indeed a considerable portion of it is evaporated or absorbed by vegetation; but in towns it runs off the roofs and paved or macadamised surfaces almost as fast as it is delivered.

Guided by these considerations, engineers have estimated that the capacity and declivity of the water-

channels for country districts should be sufficient to carry off the greatest available rainfall occurring during twenty-four hours in that space of time, whereas in towns they should be capable of discharging the greatest hourly rainfall on the area, and the greatest hourly supply from other sources. The depth of the greatest hourly rainfall is estimated by different authorities at from half-an-inch to an inch.

In small towns, where the storm-water, or greatest hourly rainfall, may be passed over the surface without causing injury, the main sewers need not be constructed of a capacity to discharge it,—a plan which has been carried out at Penzance and Carlisle. In other towns again, as at Dover, Ely, Rugby, etc., the storm-water is carried off by the old drain-sewers, and the sewage by separate pipe-sewers; or pipe-sewers are used exclusively for the sewage, and separate brick drains are constructed for the subsoil and storm-waters.

The advantages of the pipe-sewer system are, that the pipes are strong, and, if well jointed, prevent percolation; that they can be quickly laid, and require much less excavation than brick sewers; that they can be made of various curves to suit different positions; and that, with a proper declivity, they are not liable to get fouled. Another great advantage depends on the fact that the sewage can be treated without dilution, and when a pumping-station is required at the outfall, the original cost and working expenses are much lessened. On the other hand, the pipe system does not ensure the important hygienic condition of drying the subsoil if separate drains are not laid down. Drain-sewers, however, as they are usually constructed, do act efficiently as subsoil drains, and, unless the town is flat and low-

lying, or where there is any chance of the backing up of sewage from the outfall, as at Cambridge, there is little risk of percolation.

(1.) *Construction of Drain-Sewers.*—The main drains or sewers of a town are underground arched conduits, built of brick in cement, so as to be perfectly water-tight. They are generally laid on a bed of concrete, to prevent sinking of any part of the track, and consequent fracture. The cross-section preferred for them is an egg-shaped oval with the small end downwards, and with a width of at least 2 feet, to allow men to enter them for the purposes of cleansing and repair. They should be laid out in straight lines and true gradients from point to point, so that the current shall have a velocity of not less than 1 foot, and not more than $4\frac{1}{2}$ feet, per second. At each principal change of line or gradient, arrangements should be made for inspection, flushing, and ventilation; and at all junctions or curves the declivity should be increased, to compensate for friction. No sewers or drains should join at right angles, or directly opposite the entrance of others. Tributary sewers should deliver in the direction of the main flow, and should also have a fall into the main at least equal to the difference between their diameters.

Surface-drains or gutters communicate with the underground drains by gulley-holes, which are covered with gratings, and generally fitted with syphon-traps to prevent the escape of foul air. Branch drains, leading from the houses and from the adjoining ground, are usually made of earthenware pipes, bedded on concrete and well jointed in hydraulic mortar or cement. They should never be less than 4 inches in diameter, and should have a declivity sufficient to ensure a velocity

of flow of at least $4\frac{1}{2}$ feet per second, to prevent the formation of deposits. All junctions with other drains or sewers should be curved or acute-angled, and, whenever practicable, they should be made in a vertical or transversely inclined, instead of a nearly horizontal, plane. Pipes of small size should always be joined on to pipes of larger size, as 4-inch pipes into 6, 6 into 9, and 9 into 12.

No drain should ever commence in the basement of a house, otherwise the updraught produced by the increased inside temperature will occasionally draw the air through any trap. Sink-pipes, and pipes from cisterns, lavatories, or baths, should all communicate with the drains outside the building, and at each point of connection (although it is preferable that there should be no direct connection) there should be a trap with an opening on the other side for ventilation. Soil-pipes should be carried up to the roof of the house, and no other pipes should open into them. (See Chapter on Dwellings.)

(2.) *Ventilation of Sewers.*—In order to prevent concentration or stagnation of the gases which are largely given off by sewage, it becomes a matter of the utmost importance to provide numerous openings communicating with the sewers to ensure free ventilation. Main sewers, with steep gradients, should have a manhole, a tumbling bay, and double ventilating arrangement, at intervals of not less than 300 yards. The tumbling bay or fall is provided to allow of a flap-valve being applied to the discharging end of the sewer, and thus compel the gases to ascend through the ventilating shaft. One or more charcoal baskets are placed in the manhole to deodorise the sewer-air as

it escapes, and before it enters the ventilating chamber. The manhole and ventilating chamber are built side by side, and together constitute the ventilating shaft.

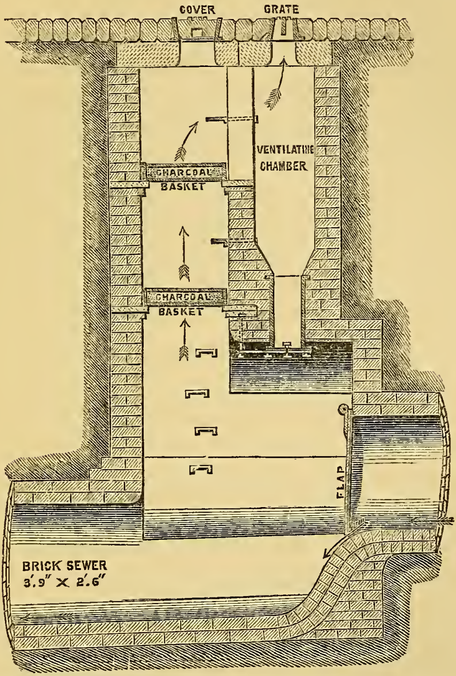


Fig. 14.—Manhole, Tumbling Bay, and Double Ventilating Arrangement. (After RAWLINSON.)

For ordinary sewer-ventilation, the manhole without a side chamber may be utilised as a ventilating shaft, and either with or without a charcoal tray, as may be deemed necessary. The charcoal best suited for the purpose is ordinary wood charcoal, broken into small pieces about the size of coffee-beans, and clean sifted. The layer in the tray or basket should never be more

than 3 inches deep, otherwise the passage of the air would be greatly retarded. Charcoal always acts most efficiently when kept dry, but it does not altogether lose its disinfecting powers when damp.

Main sewers, liable to be affected by the rise of tides or land floods, must be abundantly ventilated in order that the sewer-air may not be forced back into the tributary sewers and drains. To provide for efficient ventilation under these circumstances, Drs. Parkes and Sanderson, in their report on the sanitary condition of Liverpool, recommended the erection of lofty shafts with a sectional area at least half as great as that of the sewers. They condemned the ventilating shafts in use at the date of the inquiry as being too narrow, and ascertained by experiment that the Archimedean-screw ventilators, with which the shafts were supplied, only aided the extractive power by 20 per cent.

According to Mr. Rawlinson there should be not less than 18 fixed openings for ventilation, or 1 at intervals not greater than 100 yards, for each mile of main sewer. Flap valves, or other contrivances, should be provided for the outlet-ends of sewers, to prevent the wind from blowing in.

(3.) *Flushing of Sewers.*—As offensive discharges of sewer-air are generally due to the formation of deposits, careful attention to systematic flushing is highly essential. The flushing of sewers is effected by damming back the water, and removing the obstruction when a sufficient collection is made, the sudden rush clearing away any deposit that may have taken place. In addition to the arrangements for flushing which should be provided at every manhole, there should also be a flush-

ing chamber at the head of each sewer and drain, such chambers being flushed either from the mains where there is a public water-supply, or from water-carts. Sewers in straight lines, and even gradients from manhole to manhole, can be cleared out by using scrubbers.

No water from manufactories of an elevated temperature should be allowed to enter sewers before being cooled, because it accelerates putrefactive changes in the sewage. Blowing off steam from boilers into them is also objectionable.

With a system of sewerage properly constructed, well ventilated, and regularly flushed, the dangers arising from atmospheric pollution by sewer-gases is reduced to a minimum. Indeed, the amount of impurities in sewer-air under these conditions is so small as to be almost inappreciable to the sense of smell. If, however, offensive stenches should issue from any ventilator, a very efficient remedy is supplied by the charcoal trays first introduced by Dr. Stenhouse. The experiments of Dr. Letheby and Mr. Haywood on this point are so clear and conclusive that the results are well worth quoting. They selected for experiment a densely-populated district in the city of London, where the sewers have but a slight fall, and the currents in them are sluggish, and where the thoroughfares are mostly narrow, and therefore disagreeably affected by the sewer-gases which issue from the ventilators. Each of the 104 air-shafts in the district was furnished with a box of charcoal trays, with the result, as stated in their report, that "not only have there been no complaints from the public of stenches from the ventilating openings, but we have ascertained by actual observation that the odour of the sewer-gases is not

perceptible when they have traversed the charcoal." Their general conclusions were to the effect "that dry charcoal in the presence of the atmospheric air is a powerful means of destroying the mephitic gases and vapours of sewers and house-drains; that the charcoal air-filters may be used with efficacy in the course of the air-channels from the drains and closets of houses, as well as in the ventilation of the public sewers; that, in applying the charcoal, those contrivances should be used which offer the least resistance to the free passage of air through the charcoal; that the situation of the filter is best when the charcoal is protected from wet and from dirt, and is easily accessible; and that, from the ascertained efficacy of charcoal in destroying the dangerous emanations from sewers, the system may be generally applied with great advantage."

2. *Water-closets.*—The situation, construction, and general arrangement of the water-closet best suited for private houses, have already been described in the Chapter on Dwellings. In the crowded districts of large towns, however, the ordinary form of water-closet has proved a failure, partly on account of the complicated character of the contrivances for flushing, but chiefly on account of the carelessness and filthy habits of the poorer classes. For these reasons some special modifications of the usual plan of closet, suited for large collections of people, and whose management may be more under the control of the public authorities, have been devised and successfully introduced into several large towns. The two arrangements which have been found to answer best are the trough-closets in use at Liverpool, and the tumbler-closets in use at Leeds and Birkenhead.

(1.) The *Trough-closet* may be described as consisting of a series of closets communicating with a long trough situated beneath and behind the seats, which receives the excreta from each closet in the series. The lower end of the trough communicates with a drain leading to the sewer by an opening which is closed by a plug. Behind the back wall of the closet there is a small space to which no one has access but the scavenger, and from which alone the plug can be raised by means of a handle. The scavenger visits daily, empties the trough, washes it out with a hose connected with a hydrant, and again charges it with water. As much water is let in as will cover the excreta received during twenty-four hours, and so prevent any smell. The closets are kept clean by the users, and an inspector visits occasionally to see that cleanliness is maintained. Offenders may be summoned, and fined or imprisoned.

Dr. Buchanan and Mr. Radcliffe, in the report already alluded to, make the following observations with regard to the trough-closets:—"Nothing could be more admirable than the working of the Liverpool arrangement, and nothing could be more marked than the difference between them and what are called water-closets in the poor neighbourhoods of London and other large towns." Drs. Parkes and Sanderson, in their sanitary report on Liverpool, likewise speak very highly of them, although they found that the seats were as a rule very filthy, owing to the habit of standing on them which is practised by adults of both sexes from the fear of venereal infection. Their evidence is as follows:—"As an apparatus for the speedy and safe discharge of large quantities of excreta into a drain, we regard the trough-closet as superior to any other with which we are acquainted.

So long as the trough is full of water, the solid matters which fall into it are completely covered, and are flooded away into the sewer at the moment that the trough is discharged, as we ascertained by personal observation, in the most efficient and complete manner. Obstructive objects of an improper kind, introduced by carelessness or mischievous design, are easily removed by the scavengers in charge, so that blockage of court drains is an uncommon occurrence. The troughs are of extremely simple construction, not easily deranged, and can be worked at a comparatively small expense; for all which reasons they are better adapted for a population such as that of the Liverpool courts than any other form of water latrine."

(2.) The *Tumbler-closet* resembles the trough-closet in its general plan and structure, but differs from it in regard to the arrangements for flushing. At the upper end of the tumbler-closet trough there is a swinging basin, into which water is constantly trickling, and which is so constructed, that it capsizes whenever it becomes full. In this way the contents of the trough are every now and then washed into the drain, at longer or shorter intervals, as may be deemed necessary. These closets can be kept very clean; the water-supply is unaffected by frost; and, as the plan is self-acting, there is a saving of labour.

For barracks, prisons, etc., water-latrines of a much simpler construction than either of the above answer exceedingly well. An open metal trough roofed in, and with the necessary partitions and doors, receives the excreta, while its anterior upper margin constitutes the seat. In order that the excreta may be constantly covered, the trough should be kept one-third full of

water. It should also be well flushed at least twice daily, and the contents allowed to run off into a drain connected with a sewer. A plug or flap-door at the lower end of the trough will be required to prevent the water from draining off during the intervals.

There is a further advantage, common to all closets of the trough system, which may here be pointed out. In the event of an epidemic of cholera or enteric fever raging in the crowded courts where these closets are in use, it will be an easy matter to throw disinfectants into the troughs, and thus destroy the infectious power of the alvine discharges.

(3.) *Intercepting Tanks.*—This system of intercepting the solids and allowing the liquid part of the sewage to run off into the drains, has been advocated by many, on the grounds that the manure thus collected can be readily utilised, that there is no risk of clogging up the sewers, and that the sewers themselves may be constructed of much smaller dimensions. Many of the *fosses permanentes* and *fosses mobiles* on the Continent are constructed on this principle, and in this country a tank has been introduced by Mr. Chesshire of Birmingham, which has been well spoken of by such high authorities as Dr. Parkes, and Dr. Hewlett, health officer of Bombay. The following is the patentee's description of the tank:—"The plan or form at present preferred is that of an iron box, large enough to hold the solid part of the excreta of an average household for from eight to twelve months, and yet, when full, within the power of two strong men to lift. This box is 2 feet 4 inches long, by 18 inches wide and 18 inches deep. The pipe from the privy or closet passes into the top of the box, by preference at the

opposite corner to the outlet or waste-pipe, which, placed at the bottom of the box, is divided from the main part by a perforated grating extending across the corner and the whole height of the box. Except as to the inlet and outlet pipes, the box is hermetically sealed, though the lid can be readily removed when it is desirable to empty it. The connection of the inlet and outlet pipes to the box can also readily be separated and remade without the assistance of the plumber."

The outlet and inlet pipes are both syphon-trapped, so that, unless the disengagement of gases from the contents of the box be considerable, there would not be much danger of their escaping. On this point Dr. Hewlett has reported very favourably, and prefers the tank to the earth-closet for the interior of houses, on account of there being much less nuisance. When one tank is removed to be emptied and cleaned, a fresh one is fitted into its place.

(4.) *Urinals.*—These should be lined with glazed stoneware tiles, or enamelled slabs of smooth slate. They can be kept perfectly clean and inodorous by allowing a small quantity of water to trickle down them constantly.

Section V.—Scavenging.

It has already been shown that in several large towns where the midden system is still carried on, the house-refuse is mixed with the excreta, and both are carted away together. In the majority of cases, however, the ashes and other solid house-refuse must be collected and removed by a separate system, which necessitates the use of dust-pails or bins, and the daily or frequent visit of the scavenger's cart. For dwellings

occupied by single families, the dust-box or pail answers very well, it being large enough to contain the dry refuse collected during the twenty-four hours; and as it is emptied into the scavenger's cart at a stated time daily, any accumulation about the premises is prevented. But in crowded parts, where families live in separate tenements, the whole of the ashes and dry refuse is usually, in the first instance, emptied into a common dust-bin, and afterwards carted away when the bin becomes full. In this case it is necessary that the bin should be roofed in, in order to keep the contents dry, and that it should be well ventilated. No slops or excrement should be allowed to be thrown into it, because the former excite fermentation in the vegetable and animal matters contained in the refuse, and the latter renders the contents offensive. It need scarcely be added that, in a sanitary point of view, dust-bins should be frequently and regularly emptied.

One important branch of scavenging in urban districts is directed to the cleaning of streets and back courts, many of which are so badly constructed that it is next to impossible to prevent filth-accumulations. Gutters are often so unevenly laid, that after rain or flushing there are small stagnant pools to be seen throughout their whole extent. The surfaces of macadamised streets, again, are being constantly pulverised, and give off clouds of dust containing large quantities of decomposing animal and vegetable matter in dry weather, or are covered with liquid mud when it is wet; while paved streets present numerous interstices, which cannot be efficiently cleaned out even when scrubbing-machines and flushing are both used. There is no doubt, therefore, that the new plan of street construction which

has lately been introduced into some parts of London, and which has been so strongly advocated by Mr. Chadwick, will not only prove to be economical in many ways, but will also be productive of great sanitary advantages. The smooth and impermeable street surface supplied by the *Val de Travers Asphalte* is durable, elastic, and inodorous, and can easily be cleaned by jets of water; but a less costly surface, which will also be smooth, non-absorbent, and washable, will suffice for streets in the poorer localities, where traffic is inconsiderable. According to Mr. Chadwick, such a surface can be obtained by the use of General Scott's "Selenite," while some of the concretes or gas-tar asphaltes would be sufficiently durable for pavements and back courts.

During the summer it is very important that streets should be regularly watered, and Mr. Cooper has lately introduced a system, which has been so highly commended alike for its ingenuity and sanitary advantages, that it deserves more than a passing reference. Mr. Cooper's system consists in the use of a compound consisting of sodium, calcium, and magnesium chlorides, which is sprinkled on the streets in its dry state, or may be mixed in the water delivered by the water-cart. As the compound possesses the qualities of being deliquescent, deodorising, and disinfecting, the streets are not only kept moist, thereby effecting a considerable economy in water-supply and labour, but the effete animal matters are rendered less offensive and hurtful. When applied to macadamised streets, it is estimated that a saving of 30 per cent of road repairs is effected, and that one sprinkling of the solution is as effectual in keeping the surface moist as three sprinklings of water. The compound possesses the further advantage

of being cheap, odourless, and colourless, and is quite harmless as regards wearing apparel, carriages, etc. During the prevalence of any epidemic, the adoption of this system of street-sanitation would be especially valuable. It may be added that the system has been tried in the parish of Paddington, and has fully answerd all the expectations which have been entertained as regards its advantages in a sanitary and economical point of view.

CHAPTER XI.

PURIFICATION AND UTILISATION OF SEWAGE.

It has already been shown in the previous chapter, that of all methods of sewage-removal, the water-carriage system is the only one which meets the requirements of large towns. It is the speediest, cleanest, and, in the long run, the most economical, method which can be employed on an extensive scale, and its general sanitary advantages are now placed beyond dispute. But no sooner had this difficult hygienic problem been solved by engineering skill, than another of even greater difficulty arose. The eagerness of early sanitary reformers to get rid of human refuse at any cost blinded them to the fact that, by pouring sewage into the nearest watercourse, they were merely removing the evil from one place to take effect somewhere else. No consideration was paid to the probable results of the method on the future water-supply of increasing populations, nor to other serious consequences which speedily began to declare themselves. Rivers were in reality converted into sewers, and the communities down stream, while they loudly complained of the annoyance and danger to health, added to the nuisance by following the general example. After a time it was discovered that the mouths of navigable rivers were being silted up, that valuable stocks of fish were destroyed, that water-supplies were contaminated,

and that riparian rights were in every sense grossly violated. Such were some of the more important evils resulting from river-pollution, and eventually legal prohibitions were issued in many places to prevent their continuance. These prohibitions have multiplied, until the sanitary authorities throughout the country are at last compelled to purify the sewage of towns before it is discharged into any watercourse at a distance from the sea, or run the risk of incurring legal penalties.

Meanwhile, there was an increasing number of economists who rightly maintained that sewage was not only wasted, but worse than wasted, when discharged into rivers, and that, on account of its manurial value, its proper destination was the soil. Hence has arisen the large question of the utilisation of sewage, the merits of which will be best understood by considering first the composition of town-sewage.

SECTION I.—TOWN-SEWAGE.

In addition to excretal matters, town-sewage contains the effete products of various trades and manufactures, animal and vegetable *débris*, mineral detritus from roads and streets, and the like, all of which are held in suspension or solution by an amount of water varying according to the water-supply in the first instance, and depending, in the second place, on the rainfall and amount of subsoil-water entering the sewers at different times of the year. This varying amount of water is one of the chief difficulties to be encountered in the utilisation of sewage, and, apart from other considerations, it has led Mr. Menzies and other eminent engineers to recommend the introduction of the pipe-

sewer system, which has already been described, into all towns where sewerage-plans have yet to be carried out. The sewage, delivered from pipe-sewers, consisting almost exclusively of excretal matters, slops, and the water-supply, can of course be readily estimated in all cases, and is much more easily dealt with. But with common drain-sewers, which receive in addition the rainfall and subsoil-water, not only is the extent of dilution much greater, but it is constantly varying in amount. Thus, to quote the data given in the Third Report of the Sewage of Towns Commissioners (1865), it is considered that 60 tons per head per annum (= 36 gallons per head daily) is the average amount of normal or dry-weather sewage in the metropolis, but this amount is further increased by the rainfall and subsoil-water from two-thirds to an equal volume. With pipe-sewers, however, the amount of sewage equals the amount of water-supply, and in towns supplied on the constant system, this ought not to exceed 20 gallons per head daily, or about 33 tons per head per annum. In the face of such considerations as these, the sanitary and practical importance of Mr. F. O. Ward's famous alliterative dogma of "the rainfall to the river, and the sewage to the soil," becomes at once apparent.

But, with either system of sewers, the value of the sewage may be said to depend entirely on the excretal matters, and the amount and relative value of these will be gathered from the following data:—

According to Mr. Lawes, the subjoined table represents, as the result of numerous analyses, the average amount and composition of excretal matter discharged by a male adult daily:—

	Fresh Excrements.	Dry Substances.	Mineral Matter.	Carbon.	Nitrogen.	Phosphates.
	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.
Fæces	4·17	1·041	0·116	0·443	0·053	0·068
Urine	46·01	1·735	0·527	0·539	0·478	0·189
Total	50·18	2·776	0·643	0·982	0·531	0·257

In a mixed population, the actual amounts per individual will obviously be considerably below this average, and, according to Dr. Parkes, they may be estimated at $2\frac{1}{2}$ oz. fæcal matter and 40 oz. urine daily, an estimate which gives 25 tons solid fæces for every thousand inhabitants annually, and 91,250 gallons of urine. But the above table also shows that the manurial value of the urine voided in the twenty-four hours greatly exceeds that of the fæces passed in the same time. Indeed, the relative value, as determined by numerous analysts, is approximately as 6 to 1.

The actual value of both urine and fæces in sewage has been estimated by Messrs. Lawes and Gilbert at 6s. 8d. per individual per annum, supposing that 10 lbs. of ammonia is a fair estimate of the amount voided in that time. When the sewage averages 24 gallons daily per individual—that is, 40 tons per head per annum—its money value, according to this estimate, would be 2d. per ton, and the value per ton will decrease in proportion to the rate of dilution above this average. It may be added that this estimate corresponds very closely with the money value of average sewage given in the First Report of the Rivers Pollution Commissioners (1868); for it is there stated that the value of the "*dissolved* constituents in 100 tons of average sewage is about 15s., while the *suspended* matters only contain

about 2s. worth of them." In other words, 100 tons are worth 17s., or about 2d. per ton.

These monetary details are quoted here because they largely affect the question of utilisation of sewage, and have more or less influenced the various plans which have been proposed or carried out in this direction.

SECTION II.—SCHEMES FOR THE PURIFICATION AND UTILISATION OF SEWAGE.

These have generally been classified under the separate headings of, precipitation, filtration, and irrigation processes, and the more important of them are as follows:—

1. *Precipitation processes.*—In all of these processes, the main object in view is the purification of sewage by the introduction of chemical agents. The dissolved matters are precipitated to a greater or less extent, and can therefore be separated along with the suspended matters, while the effluent water is supposed to be in a sufficiently pure state to allow of its being discharged into a stream or river without producing any serious degree of pollution.

(1.) *Precipitation by Lime.*—This process has been carried out on an extensive scale at Blackburn, Leicester, and Tottenham. It consists in mixing the sewage at the outfall works with a certain proportion of cream of lime, when a copious precipitate takes place, which may be sold as manure or converted into bricks. The supernatant fluid flows off in a comparatively clear though milky condition, but contains about half the putrescible matter of the sewage, and a great proportion of the fertilising constituents. The plan has been pronounced

by the Rivers Pollution Commissioners to be a conspicuous failure, "whether as regards the manufacture of valuable manure, or the purification of the offensive liquid."

At Northampton, a modification of this process, by the addition of iron perchloride and subsequent filtration through calcined iron ore, has been tried, but with little better results. Other salts, such as salts of zinc and manganese, and carbolates of lime and magnesia, have also been proposed as adjuvants to the lime-process, but they all fail in separating the ammonia and other manuring material. They disinfect the sewage for the time being, but do not prevent subsequent decomposition.

(2.) *Blyth's process* consists in the addition of a salt of magnesia and some lime superphosphate, or superphosphate of magnesia and lime water, with the view of purifying the sewage by the formation of the triple phosphate of magnesia, ammonia, and water. Such a precipitate, however, can only take place in water containing an excess of ammonia; so that the whole process, while being more costly than others, was found to be as inefficient.

(3.) In *Holden's process,* a mixture of iron sulphate, lime, coal-dust, and clay, is added to the sewage, but it fails to remove the nitrogenous matters in solution, and indeed increases their amount by dissolving some of the suspended constituents.

(4.) *Bird's process,* which has been tried at Cheltenham, but latterly abandoned, consists in the addition of crude sulphate of alumina, and subsequent filtration through coke. The sulphate of alumina was obtained by treating pulverised clay with strong sulphuric acid.

In this and Stotherd's process, which somewhat resembles it, the effluent liquid was not found to be sufficiently purified for admission into a river without creating a nuisance.

(5.) *The "A B C," or Sellar's process.*—This process, which has attracted so much attention during the last few years, has had a prolonged trial at Leamington on an extensive scale, and is at last pronounced to be a failure. It consists in adding a mixture of alum, blood, clay, charcoal, a salt of manganese, and other ingredients, to the sewage as it enters the works. A precipitate is thus obtained, which settles to the bottom of the tanks in the form of a soft black mud. This is afterwards pumped up into receptacles, from which it runs into centrifugal drying machines, or is removed into drying chambers. But in either case it is subsequently spread out on the ground to complete the drying process, and the mass is from time to time sprinkled with sulphuric acid to fix the ammonia. The manure-manufacture is at times productive of great nuisance, and the manure itself, though it has sold well, does not pay the cost of working. Its real agricultural value has been estimated by Dr. Odling at 11s. 3d. per ton. The effluent water contains a large amount of putrescible matter, and according to Professor Corfield, who visited the works at Leamington in July 1870, the surface of the river near the outfall was covered with a filthy scum. It would appear, from the conclusions of the Rivers Pollution Commissioners, that, though it is superior in some respects to the processes already described, it is nevertheless an inefficient purifier.

(6.) *The Phosphate process,* as proposed by Messrs. Forbes and Price, has been experimented on at Totten-

ham. It consists in adding to the sewage a solution of the native phosphate of alumina, dissolved in sulphuric or hydrochloric acid, and diluted in water. The resulting manure has been estimated by Dr. Voelcker at £7 : 7s. per ton. The effluent water is clarified and disinfected, but not by any means freed from putrescible or fertilising matters, and the originators of the process have themselves pointed out that it is only intended as a preliminary step to irrigation, where that can be carried out. Where irrigation is impossible, the process is completed by adding milk of lime, to precipitate the phosphates in solution.

(7.) *Hillé's process* is carried on at Wimbledon. The mixture in this case consists of lime, tar, calcined magnesium chloride, and some other substance not named. The lime is slaked, and the tar added while it is hot. The whole ingredients are subsequently mixed with water, and flow through a large tap into the tank which receives the sewage. Here precipitation takes place, and the sewage, completely deodorised, passes into a second tank, where the deposit settles. The effluent water is afterwards filtered through a charcoal basket into a third tank, is received into a fourth, and overflows from this into a small brook. The working expenses of the process are small, but the manure is not valuable.

(8.) *General Scott's process* differs from others already described, in the introduction of the chemicals into the sewer at some considerable distance from the outfall. The precipitating agents consist of lime and clay properly pulverised, and the motion of the sewage in its onward flow ensures their thorough admixture with itself before it reaches the outfall. The resulting sludge which is formed, instead of causing any deposit in the

sewer, as some anticipated, acts rather as a scouring agent, and keeps the sewer clean. When received into the outfall tanks, the sewage is found to be deodorised, and here the suspended matters are deposited. These are subsequently removed to be dried and burnt, and are thus converted into a useful cement. The drying process, it appears, is not attended with any nuisance.

The British Association Sewage Committee report favourably on the whole process, as solving one of the difficulties of the sewage question, namely the separation and deodorisation of the offensive ingredients in an efficient manner, at a comparatively small cost, and of easy application on a large scale. The effluent water, according to the Committee's analysis, contains rather more than two-thirds of the chlorine and of the dissolved nitrogen of the sewage. It is therefore too valuable to be wasted, and too impure to be discharged into a river, and can only be properly dealt with by irrigation.

General Scott's process has been carried on for some time at Ealing; it has also very recently been adopted by the Local Board of West Ham, and the Town Council of Birmingham.

(9.) *Whitthread's process,* which has also been favourably reported on by the British Association Committee, consists in adding to the sewage a mixture containing two equivalents of dicalcic phosphate, one of monocalcic phosphate, and a little milk of lime. The resulting precipitation was found to be very rapid, and the supernatant fluid clear and inoffensive. Suspended matters were completely removed, and the organic nitrogen nearly so. It was considered by the Committee that the manure would be valuable, as it con-

tained a large amount of lime phosphate and 3 per cent of ammonia. As the effluent fluid contained phosphoric acid and ammonia, it would be suitable for irrigation.

(10.) *Dr. Anderson's process* is now being tried at Nuneaton. It consists in adding an impure sulphate of alumina, made by dissolving aluminous shale in sulphuric acid, to the sewer water in the tank. The process has been highly spoken of.

2. *Filtration processes.*

(1.) *Simple Filtration.*—In this process the sewage is merely strained or screened, so that, although almost all the suspended matters are removed, the effluent fluid is not by any means purified. The mud which collects at the bottom of the filtering tanks is generally mixed with the town ashes and sold as manure.

(2.) *Carbon Filtration, or Weare's process.*—This process is carried on at the Stockton-upon-Trent Workhouse The filtering tanks are all underground, to prevent nuisance. The first, or large tank, is divided into two compartments, so that one can be used while the other is being cleared out, and each of these is further subdivided into two chambers of unequal size. In the larger chamber the sewage is filtered through coarse ashes, and the greater portion of the suspended matters retained. It then passes into the smaller chamber, from which it filters through a layer of vegetable charcoal to a series of tanks, also containing charcoal of smaller size, and supplemented in the last tank by layers of filtering cloth, and is finally discharged into a drain. The deposit from the tanks is used as manure on the Union farm.

According to the report of the British Association

Committee, presented recently at the Brighton meeting, the effluent water can only be regarded as diluted sewage, although the general result of the process is "to remove the suspended matter, and much to reduce the quantity of ammonia and organic nitrogen."

(3.) *Upward Filtration.*—This process has been carried on to a certain extent at Ealing, but the results have not been satisfactory.

(4.) *Intermittent Downward Filtration.*—Amongst the numerous important experiments conducted under the direction of the Rivers Pollution Commissioners, there were none attended with better results than the filtration of sewage through a considerable depth of soil. The experiments were made on sand, on a mixture of sand and chalk, and on different soils. The results varied a good deal according to the quality of the soil, but in all of them it was found that the suspended matters were entirely removed, and that the organic carbon and nitrogen were greatly reduced. According to the report of the Commissioners, "these experiments also show that the process of purification is essentially one of oxidation, the organic matter being to a large extent converted into carbonic acid, water, and nitric acid; hence the necessity for the continual aëration of the filtering medium, which is secured by intermittent downward filtration, but entirely prevented by upward filtration."

The process has for some time been carried on at Merthyr Tydfil, and the following abstract from the report of the British Association Sewage Committee will afford a sufficient description of the various details and the results:—The filtering area or farm is about 20 acres in extent, and consists of a very porous gravelly

subsoil covered with vegetable mould. It has been pipe-drained to the depth of about 7 feet, the drains conveying to the lowest corner, where the effluent water is discharged into a small stream leading into the river Taff. The area is laid out in square beds, intersected by paths, along which are constructed the main carriers, which receive the sewage from the outfall sewer, where it is screened through a bed of clay, and distribute it over the beds. In order to supply the sewage on the intermittent system, the area is divided into four equal portions, each portion receiving the whole of the sewage for six hours in succession, and thus leaving an interval of eighteen hours for rest and aëration of the soil. The surface of the land is cultivated to a depth of about 18 inches, and is laid up in ridges to allow of the sewage running down the furrows. The ridges are planted with cabbages and other vegetables.

The results of the process, as stated by the Committee, are highly satisfactory. All the suspended matters are removed, and the ammonia and nitrogenous organic matters are almost completely oxidised, so that they escape in the effluent water as nitrites and nitrates. They add, however, that though the sewage is thus efficiently purified, the process cannot be regarded as one of utilisation.

The requisite extent of filtering area, as estimated by the Rivers Commissioners, is 1 acre drained to a depth of 6 feet for every 3300 of the population, but this ratio must vary according to the nature of the soil.

3. *Irrigation.*—It is now generally conceded that this is the only process which fully meets all the requirements ataching to the disposal of sewage; in other words, it is the only one which, while it purifies the sewage

efficiently, realises the highest profits, and may be carried on without creating any nuisance or detriment to the health of the neighbouring inhabitants. But, in order that the process may be carried out satisfactorily, it is necessary,—

(1.) That the acreage be sufficient. This will depend in great measure on the looseness or porosity of the soil;—hence to lay down as a rule that 1 acre should be allowed for every 100 inhabitants, which is the estimate usually given by engineers, is manifestly illogical.

(2.) The land to be irrigated must be drained, and stiff clayey soils broken up and mixed with ashes, sand, or lime.

(3.) The surface must be irrigated on the intermittent system, to ensure sufficient aëration of the soil.

(4.) The ground should be laid out in broad ridges and furrows, the sewage being conveyed along the tops of the ridges in open carriers, and made to flow gently down the slopes by inserting temporary sluices in regular succession and at regular intervals. At Breton's Farm, near Romford, rented by Mr. Hope, the breadth of the ridge is 30 feet, giving a slope of 15 feet on either side of the carriers.

(5.) There must be a rotation of crops, such as ryegrass, peas, maize, different roots, cabbages, etc.

(6.) The sewage should be delivered in a fresh state, and freed from the greater portion of its suspended matters. This may be effected either by precipitation, filtration, or screening.

Such, briefly, are the principal details connected with sewage-farming, and it is the neglect of one or more of them which has brought so much opprobrium on the system. If the irrigated soil becomes water-

logged and swampy, the fault lies with the engineering and management, not with the system. Or, again, if the works become a nuisance, it is because the sewage is not properly prepared and disinfected before it is distributed.

The average profit per head of population, after deducting the percentage for outlay in the preparation of the farm, and working expenses, ranges from 2s. to 3s. 9d., and there is little doubt that when the system becomes more widely known and appreciated, the money results will considerably exceed even these.

The general advantages of the system will be best given in Professor Corfield's own words, from whose Work many of the facts here given have been collated. His conclusions are as follows:—

" (*a*) That by careful and well-conducted sewage-irrigation, especially with the application of moderate quantities per acre, the purification of the whole liquid refuse of a town is practically perfect, and has been ensured in cases where it was not at all the object of the agriculturist; and that it is the only process known by which that purification can be effected on a large or small scale.

" (*b*) That perfectly worthless land, blowing sea-sand for instance, can be made in this way to support large and valuable crops.

" (*c*) That the quantity per acre of all crops obtained from even the best land is enormously increased.

" (*d*) That it reduces to a great extent, or renders entirely unnecessary, the usual amount of artificial manures of all kinds, by supplying a manure especially adapted, from its complex constitution, for the nourishment of crops, supplying it, moreover, in a state of so-

lution—that is to say, in the most readily absorbable condition, and supplying at the same time that most necessary aid to vegetation, water, which often converts what would otherwise have been a very heavy loss into a very handsome profit.

"(*e*) That by it the farmer is rendered entirely independent of drought, so that he can be practically certain of his crops, and moreover be able to transplant them as much as he pleases.

"(*f*) That, with all these advantages, it is no wonder that it has been found to pay; and when its management is more thoroughly understood, it will doubtless be found to be a valuable source of income to towns." (*Treatment and Utilisation of Sewage*, 2d Edit.)

The comparative results of the different processes of purification are stated by the Rivers Pollution Commissioners as follows:—

Average Results.

	Percentage of dissolved Organic Pollution removed.		Percentage of suspended Organic Impurity removed.
	Organic Carbon.	Organic Nitrogen.	
Chemical processes .	28·4	36·6	89·8
Upward filtration . .	26·3	43·7	100·
Downward filtration .	72·8	87·6	100·
Irrigation	68·6	81·7	97·7

This table shows that, in order to obtain the best purifying results, irrigation should always be combined with intermittent downward filtration. With regard to towns where a sufficiency of land cannot be procured for irrigating purposes, the process of downward filtra-

tion, as carried on at Merthyr Tydfil, should be adopted, and, in either case, the ashes and other town-refuse can be largely used in clarifying or disinfecting the sewage before it is delivered on the filtering ground. Trade or manufacturing pollution must be treated according to the nature of the pollution.

CHAPTER XII.

THE EFFECTS OF IMPROVED DRAINAGE AND SEWERAGE ON PUBLIC HEALTH.

This subject may be conveniently considered as follows:

1. The effects of dampness of soil on the public health.
2. The sanitary aspects of the water-carriage system of excretal removal.
3. The sanitary aspects of sewage-irrigation.

Section I.—The Effects of Dampness of Soil on Public Health.

Amongst the numerous valuable reports which Dr. Buchanan, in his capacity of Health-Inspector, has submitted to the Privy Council, there is perhaps none which excited greater interest at the time than his report "On the Distribution of Phthisis as affected by Dampness of Soil." In a previous investigation regarding the effects of improvements in drainage and water-supply, Dr. Buchanan had ascertained that in certain towns which had been improved in this respect, the mortality from phthisis had greatly diminished; and not only so, but the rate of diminution was found to correspond with the extent of the drying of the subsoil. This result, which was so far unexpected, led to the important inquiry above mentioned, and the principal

facts connected with both may be briefly summarised as follows :—

In the first inquiry, it was found that wherever the drying of the subsoil had been effected, either by the construction of drain-sewers, or by special drains and deep storm-culverts, when the pipe-system was carried out, the mortality from phthisis had decreased from about 50 per cent downwards. In Salisbury, for example, the death-rates from phthisis had fallen 49 per cent; in Ely, 47; in Rugby, 43; in Banbury, 41; and in 13 other towns, the rate of diminution, though not so marked, was nevertheless noteworthy. On the other hand, it also became apparent that in certain towns, such as Alnwick, Stafford, Morpeth, and Ashley, where no drying of the subsoil had been effected, there was no reduction in the phthisis death-rate, even although the greatest possible progress had been achieved in the removal of filth. This was owing to the fact, that in these towns impervious pipe-sewers had been laid down, without making any provision for deep subsoil-draining, the storm-water being carried off in superficial culverts. In some towns, again, such as Penzance, where the subsoil was already dry, the phthisis death-rate remained stationary; and in others, where plans of drainage had been carried out, the sanitary advantages, as regards phthisis, were nullified, because, as in the case of Carlisle, they were so low-lying that the subsoil was at all times more or less waterlogged. So far, therefore, the relation between dampness of soil and phthisis, as one of cause and effect, became highly probable, and Dr. Buchanan's second inquiry converted the probability into a scientific certainty.

In this special inquiry (see *Tenth Report of the Medical Officer of the Privy Council*) the various registration-districts in the three south-eastern counties of England, beyond the limits of the metropolis, were brought under detailed examination, and considered in two ways. Firstly, the true phthisis-rate of the population was ascertained, and due allowance made for the causes of the disease which were likely to influence the rate besides the nature of the soil; and secondly, the numbers of the population, in each district, that were found "living upon various kinds of soil, and under various topographical conditions," were also noted. The results of these two separate lines of investigation were then brought together, and statistically compared.

Without entering into any of the geological details which are fully given in Dr. Buchanan's report, it may be said generally, that the dampness or dryness of a soil depends partly on whether, if pervious, it is retentive of water, or, if impervious, the water can readily drain away. Again, it is obvious that pervious soils may present very different degrees of dryness or wetness, according to the elevation of the ground, and the dip of underlying impervious beds. Thus, a stratum of gravel or chalk, covering a sloping bed of impervious clay, is necessarily a dry soil, because the rainfall readily sinks to and flows along the surface of the impervious slope, whereas the same stratum in a valley may be actually water-logged, although the depth of the stratum may be the same throughout. Bearing in mind, then, the topographical relations as well as the physical qualities of different soils, the following general conclusions, given by Dr. Buchanan as the result of his inquiry, will be at once understood:—

"(1.) Within the counties of Surrey, Kent, and Sussex, there is, broadly speaking, less phthisis among populations living on pervious soils than among populations living on impervious soils.

"(2.) Within the same counties there is less phthisis among populations living on high-lying pervious soils than among populations living on low-lying pervious soils.

"(3.) Within the same counties there is less phthisis among populations living on sloping impervious soils than among populations living on flat impervious soils.

"(4.) The connection between soil and phthisis has been established in this inquiry—

"(*a*) By the existence of general agreement in phthisis-mortality between districts that have common geological and topographical features, of a nature to affect the water-holding quality of the soil;

"(*b*) By the existence of general disagreement between districts that are differently circumstanced in regard of such features; and

"(*c*) By the discovery of pretty regular concomitancy in the fluctuation of the two conditions, from much phthisis with much wetness of soil to little phthisis with little wetness of soil.

"(5.) The whole of the foregoing conclusions combine into one—which may now be affirmed generally, and not only of particular districts—that wetness of soil is a cause of phthisis to the population living upon it."

It is interesting to note that this new discovery in the etiology of disease, which in this country will always be associated with Dr. Buchanan's name, had already been made a matter of probability by Dr. Bowditch

of Boston, U.S. Dr. Bowditch's researches, however, were not known in England until after Dr. Buchanan's inquiry had been finished; and although the priority rests with him, the credit of establishing causation of phthisis by dampness of soil as a general law remains with Dr. Buchanan. But it would be unfair not to quote Dr. Bowditch's own remarks. In an address, delivered to the Massachusetts Medical Society in 1862, he represented that "medical opinion in Massachusetts, as deduced from the written statements of resident physicians in 183 towns, tends strongly to prove, though perhaps not affording perfect proof of, the existence of a law in the development of consumption in Massachusetts, which law has for its central idea, that dampness of the soil of any township or locality is intimately connected, and probably as cause and effect, with the prevalence of consumption in that township or locality."

But, in addition to phthisis, there are other diseases whose prevalency is largely affected by dampness of soil. Thus, rheumatism, catarrhal complaints, and ague, are especially common in damp districts; and no greater proof can be given of the sanitary advantages arising from drainage on an extensive scale than the total disappearance of the last-named disease in various parts of the country where it was at one time so common. Moreover, it is evident that in towns situated on damp pervious soils, there is the constant danger of filth-accumulations finding their way by soakage into surface-wells, or, as has previously been shown, the soil may eventually become excrement-sodden, so that the air, as well as the well-water, becomes polluted. It is in this sense that the views of Pettenkofer with

regard to the spread of cholera and enteric fever become so important, for he insists on humidity of soil as a necessary factor in the etiology of any localised outbreak of either disease.

An undrained or damp state of soil, especially in populous places, is thus fully proved to be highly inimical to public health, and, according to Mr. Simon, it answers to the legal definition of the term "nuisance." Sanitary authorities are therefore "bound to provide that such a state shall not continue through want of proper constructions for the drainage."

Section II.—Sanitary Aspects of the Water-Carriage System of Excretal Removal.

So much has already been said with regard to the evils resulting from collections of excretal matter in towns, that, at first sight, the superiority of any system which prevents these accumulations would appear to be placed beyond dispute. Unfortunately, however, the sewer-system is by no means free from serious dangers, and these have at times been attended with such disastrous consequences, that many have been led to condemn it altogether. But an examination of a few of the more important outbreaks of disease, which have been attributed to the introduction of sewers, will show that such wholesale condemnation is groundless; that in fact such outbreaks are due to faults in the system, and not to the system itself. Thus, in the first inquiry of Dr. Buchanan, already alluded to (*Ninth Report of the Medical Officer to the Privy Council*), it was found that at Chelmsford the death-rate from enteric fever had increased, since the introduction of the sewer-

system, 5 per cent, and at Worthing it had increased 23 per cent. In both these places, however, there was backing up of the sewage, and, as a consequence, the sewer-gases were forced up into the houses. At Chelmsford, the sewage was received into a tank or underground well; and, at times, when the pumping-engine was not at work, the well filled, and choking of the outfall-sewer, and flooding of the cellars, ensued. At Worthing, again, although there was not so much backing up of the sewage, there was no provision made for ventilation; and hence, in the outbreak of 1865, the disease "almost exclusively attacked the well-to-do occupants of houses on the higher levels, where the water-closets were inside the houses, and almost entirely spared the houses, mostly of a much poorer sort, situated on lower levels, where the closet was placed outside the house. It was not so in the times of cess-pools; then these low-lying poor houses were far more attacked with fever than the others." At Morpeth it was also observed that occasional outbreaks of enteric fever had followed times of flood, during which the outfall sewer was under water.

Other instances of a similar character might easily be multiplied, but these are sufficient to show that all such outbreaks are due either to faulty construction, deficient ventilation, or imperfect flushing of sewers, or to backing up of sewage in low-lying towns. But while outbreaks of enteric fever do occasionally take place through the agency of sewers, there was no point more clearly established in the whole of Dr. Buchanan's inquiry, than the remarkable reduction of the death-rate from this disease which had taken place in almost all the towns where a system of sewerage had been carried

out. Thus, in nine of the twenty-five towns examined, the diminution in the number of deaths was over 50 per cent, and in ten others from 33 to 50 per cent, the average reduction being about 45 per cent. The same kind of evidence is also afforded in the account of the sanitary condition of Liverpool, given by Dr. Trench in 1868. Dr. Trench writes:—In 1868 "there raged a widespread epidemic of typhoid fever in the town, and in the rural districts of the town. . . . While in the families of the rich, in their costly suburban dwellings, there was raging a fever, clearly and unmistakably due to the pestiferous emanations from ill-drained cesspools, or other collections of filth or decomposing organic matter, the districts in the borough of Liverpool known as the fever districts, and wherein no midden-steads or cesspools were allowed by the Council to remain unaltered, continued, during the whole period of the epidemic, remarkably healthy, and free from fever."

As regards other diseases, it appears that cholera epidemics had been "rendered practically harmless" in all of the twenty-five towns examined by Dr. Buchanan; and in the majority of cases the death-rate from diarrhœa had also been considerably reduced. Moreover, the general death-rate was lowered in some towns over 20 per cent; and the progress made by the inhabitants in cleanliness, decency, and self-respect, was found to be as striking as the improvement in their health measured by the mortuary returns. No doubt, the improved water-supply, which was generally obtained at the same time, aided in the common health-amelioration, but there can be little question that the system of excretal removal by water-closets and sewers was the real agent at work.

Section III.—Sanitary Aspects of Sewage Irrigation.

It has already been shown in the previous chapter that irrigation is the only method of sewage disposal which sufficiently purifies the sewage, and, at the same time, secures a profitable agricultural return. It now remains to be seen whether the carrying out of the system is attended with danger to public health. And here it may be premised that the same difficulty is encountered in sifting evidence as throughout the whole sewage-question,—the difficulty, namely, of dealing with sweeping generalisations which have been based on isolated or exceptional cases. For while, on the one hand, it appears that Dr. Letheby and others condemn all sewage farms as pestilential swamps, Dr. Carpenter of Croydon and other strenuous advocates of the system, so far from pronouncing them as in any way dangerous to health, maintain that the general health of the neighbouring inhabitants is actually improved by them. But this is pushing the argument perhaps too far on both sides. No doubt, some sewage farms answer to Dr. Letheby's description, especially such farms as have been laid out, without any due regard to drainage, in low-lying districts, and those that have been planned on the "catch-water" system. It is evident that this latter system necessitates a swampy condition of both soil and subsoil, inasmuch as the sewage passes over successive areas of land, overflowing from each into a "catch-water" ditch, which conveys it to the next. Again, when the sewage is not delivered in a fresh state, and at least properly strained, if not disinfected by some precipitation process, offensive em-

anations are undoubtedly given off, and may become productive of serious disease. But though all this is perfectly true, it is no argument against the system when properly carried out, unless direct evidence can be brought forward to show that, even when the engineering and management are alike satisfactory, there is not only possible but actual risk to health. Such evidence, however, does not appear to be forthcoming; and even with regard to farms which have neither been planned nor are conducted according to the most approved principles, the evidence as regards the production of disease is of a negative character. Thus, Sir Robert Christison testifies concerning the Craigentinny Meadows, near Edinburgh—"I am satisfied neither typhus, nor enteric fever, nor dysentery, nor cholera, is to be encountered in or around them, whether in epidemic or non-epidemic seasons, more than in any other agricultural district of the neighbourhood." (*First Report of the Rivers Pollution Commissioners.*) At Norwood, again, where the farm lies on a deep clay soil, Dr. Cresswell states that the health of the neighbouring inhabitants is in no way influenced by it; and according to the Ninth Report of the Medical Officer of the Privy Council, the irrigation works at Worthing do not cause any description of nuisance or injury to health. So far, therefore, the production of disease arising from fæcal pollution of air or water by the system, when properly managed, is not substantiated. But it was feared at one time that entozootic diseases would be greatly propagated, no matter how efficiently the system might be carried out, and Dr. Cobbold's high authority gave currency to the belief. Dr. Cobbold, however, with rare scientific candour, and after

careful investigation, has recently stated that the fears which he originally entertained have not been realised. Animals fed on sewage produce have not been found to be parasitically diseased, nor has any case of parasitism been detected in man which could be traced to the effects of sewage irrigation.

General Conclusions.—Having regard to the practical as well as sanitary aspects of the whole of this subject, the following points of detail may be noticed :—

1. All towns and villages situated on a pervious or damp soil should be drained.

2. Where there is a good outfall, and no difficulty with regard to the disposal of the sewage, drain-sewers will suffice for drainage as well as for sewage-removal.

3. In low-lying towns, and where the sewage has to be pumped to a higher level at the outfall, pipe-sewers are required.

4. Towns supplied with pipe-sewers should have a separate system of drainage for the removal of the storm and subsoil water.

5. Wherever it is practicable, the sewage should be purified and utilised by the process of irrigation, or, where sufficient land cannot be procured, by intermittent downward filtration. Purification by either process will be greatly assisted by previously treating the sewage according to one or other of the most approved precipitation-processes.

CHAPTER XIII.

PREVENTIVE MEASURES—DISINFECTION.

THE remarks in this chapter will have reference chiefly to the prevention of infectious diseases, and to the adoption of measures best calculated to check their progress when they become epidemic, or threaten to become epidemic, in any locality. By infectious diseases are meant all diseases which are communicable from one person to another, whether by actual contact or through the agency of certain media, such as air or water. Many of these, however, are comparatively of such little hygienic concern, that they may be excluded from further notice, as, for example, certain parasitic diseases of the skin, and others, which are never found to affect communities in an epidemic form. The preventive measures, therefore, or other protective means, which will be here considered, apply mainly to the class of diseases termed zymotic, such as smallpox, cholera, typhus fever, enteric fever, scarlet fever, relapsing fever, measles, and the like. Whether or not these diseases are capable of being originated *de novo,* is not a fit question to be discussed here; nor is it necessary to enter into any speculations regarding the nature of the various *materies morbi.* The points of practical importance to be borne in mind are rather these,—that however they may have been produced originally, they are undoubtedly com-

municable; that their communicability is largely due to sanitary defects, or neglect of proper precaution; and that by adopting suitable measures, their prevalence may be greatly controlled, even if the diseases themselves cannot be stamped out altogether.

But whilst this is so far true, it must also be noted, that, apart from the influence of personal susceptibility, or of sanitary defects, on the contagiousness of any of these diseases, there are certain other influences, obscurely called epidemic, which appear to act as predisposing causes, or, at all events, to give increased energy to causes already in operation. Such epidemic influence, however, is merely the expression of the fact that we cannot always explain why it is that certain diseases should rage with terrible violence in a particular locality at one time and not at another; or why the type of the disease should now be mild and now severe; or why, again, a disease, such as cholera, should be subject to periods of pandemic extension. All these are questions which still afford ample room for speculation and research. Meanwhile it is encouraging to sanitary efforts to find that as civilisation advances, epidemics decrease in frequency and intensity, and that nothing tends so much to weaken their power and circumscribe their range of action, as a free circulation of pure air in inhabited places, a good supply of pure water, and a sufficiency of wholesome food.

In preceding chapters the mode of propagation of several of these diseases has been considered more or less fully in detail. It has been shown, for example, that there is good reason to believe that the contagia of cholera and enteric fever are contained in the alvine discharges, which, in their turn, pollute the water-supply

or the respired air; that typhus fever is essentially a disease of overcrowding; and that relapsing fever is associated with wide-spread insufficiency of food. It has also been shown, that when the local circumstances which are found to favour the propagation of any one or other of these diseases in an epidemic form are improved, the extension of the disease is checked, and its ultimate extinction from a portion of the community secured. Improvement of local circumstances is, therefore, a most important, and perhaps the most important, part of prevention. But there are other measures which are found to be of immense service in checking the course of any epidemic,—such as the isolation of the sick, the use of disinfectants, and the destruction of the contagia by any other means which may be deemed most efficacious. In order, however, to be able to apply these measures judiciously, some knowledge of the mode of propagation of the several epidemic diseases is essential, and this part of the subject may be briefly discussed as follows:—

Section I.—Mode of Propagation of Epidemic Diseases, and the Precautionary Measures indicated.

1. *Cholera.*—The basis of precautionary measures with regard to this disease is thus described by Mr. Simon:—"That, when cholera is epidemic in any place, persons who are suffering from the epidemic influence, though perhaps with only the slightest degree of diarrhœa, may, if they migrate, be the means of conveying to other places an infection of indefinite severity; that the quality of infectiveness belongs particularly, if not

exclusively, to the matters which the patient discharges, by purging and vomiting, from his intestinal canal; that the matters are comparatively non-infective at the moment when they are discharged, but subsequently, while undergoing decomposition, acquire their maximum of infective power; that choleraic discharges, if cast away without previous disinfection, impart their own infective quality to the excremental matters with which they mingle, in drains or cesspools, or wherever else they flow or soak, and to the effluvia which those matters evolve; that if the cholera-contagium, by leakage or soakage from drains or cesspools, or otherwise, gets access, even in small quantity, to wells or other sources of drinking-water, it infects, in the most dangerous manner, very large volumes of the fluid; that in the above-described ways even a single patient with slight choleraic diarrhœa may exert a powerful infective influence on masses of population among whom perhaps his presence is unsuspected; that things, such as bedding and clothing, which have been imbued with choleraic discharges, and not afterwards fully disinfected, may long retain their infectious properties, and be the means of exciting choleraic outbreaks wherever they are sent for washing or other purposes." (*Eighth Report of the Medical Officer of the Privy Council.*)

The practical applications of the above remarks are therefore these,—that the alvine discharges and vomited matters, as well as any clothing or bedding tainted by them, should be carefully disinfected; and that, if this is carefully attended to, there is little or no risk of infection by direct contact with the patient.

2. *Enteric Fever.*—Exclusive of the epidemic influence, what has been said of cholera may be said of

enteric fever. The evacuations, and any clothing tainted with them, should be disinfected. The water-supply should be examined; and, in localities where the sewer-system has been introduced, the condition of the water-closets and drains, with regard to ventilation and trapping, should be carefully inquired into. Any epidemic of enteric fever in a sewered town provided with a public water-supply points to imperfect ventilation, deficient flushing, or to some faulty construction of the sewers or drains; and in small villages where there are no sewers, it points to contamination of the wells by soakage from cesspools, midden-heaps, or other filth-accumulations.

If proper precautions are taken, there is in this case also little or no risk that the disease will spread to persons who nurse or otherwise closely attend upon the sick.

3. *Typhus Fever.*—The conditions essential to the propagation of typhus fever are mainly these:—overcrowding and deficient ventilation; clothing saturated with cutaneous exhalations; squalor and want; a deteriorated state of the constitution from whatever causes; and a moderate temperature.

The disease, once generated, is highly contagious, the contagium being thrown off by the cutaneous and respiratory exhalations. The air of the sick-room is therefore contaminated, and by this means the contagium may attach itself to the walls of the room, or to furniture, or to bedding and clothing, and may long retain its efficacy if fresh air is excluded. Cases are not at all uncommon in which the disease has been communicated to persons who have been employed in cleaning out places which had been occupied by the sick, even

though some considerable time had elapsed after the sick had been removed.

But the contagium does not travel far through the air, for, according to Dr. Murchison's observations, it appears that if a patient is placed in a well-ventilated room, the attendants incur little risk, and the other occupants of the house none whatever. Dr. Russell, of the City of Glasgow Fever Hospital, also reports to the same effect, and, in addition, deduces from his experience other points of practical importance. Thus, in his report for 1870, he writes—"All these facts concur in proving (1) that, where attention is paid to personal and general cleanliness, typhus does not carry far, so to speak, through the atmosphere, and is not portable; (2) close approach to, and contact with, the infected individual and his dirty belongings, lead with great certainty, even in the best sanitary circumstances, and in healthy and well-fed people, to an attack at the end of about four weeks in the great majority of cases, but not in a few until the lapse of some months; (3) that individual susceptibility does not exist, except that which is conferred by a previous attack."

As regards the period of the disease at which the contagium is most powerful, there is a difference of opinion. Dr. Murchison believes that the disease is most readily propagated from the end of the first week up to convalescence—that is, during the period when the peculiar typhus smell from the skin and lungs is the strongest.

The practical deductions from these observations are as follows:—The sick should be isolated as much as possible; the attendants, by preference, should be those who have been protected by a previous attack; others

who visit the sick should avoid coming into close contact with them; the room should be well ventilated by open windows and fires if necessary; all extraneous furniture, such as carpets and curtains, should be removed and disinfected; disinfectants should be constantly used in the room; the bedding and clothing should be disinfected or destroyed; and after convalescence, the whole room, and every piece of furniture, should be purified.

4. *Relapsing Fever.*—Excluding for the present the consideration of the public measures which should be adopted when an epidemic of relapsing fever is raging, the hygiene of the sick-room should be conducted in the same manner as in the case of typhus fever. The disease, however, is much less frequent than typhus, and though contagious in the same way, is not contagious to the same extent. It selects its victims from the poor and ill-fed, who live in crowded, unventilated buildings, rather than from the well-nourished, whose surroundings are healthy.

5. *Smallpox.*—"There is no contagion," writes Sir Thomas Watson, "so strong and sure as that of smallpox; none that operates at so great distance." The contagium indeed may be wafted from house to house on opposite sides of a street, and, even with every sanitary precaution, there is great difficulty in preventing its spreading from ward to ward in a large hospital when the disease is prevalent. The poisonous material is thrown off from the cutaneous and mucous surfaces of the patient, and is contained in the exhalations, the excretions, the secretions, the matters in the vesicles and pustules, and in the scabs. It contaminates the air of the sick-room, and attaches itself, as in typhus, to

everything contained in the room, or which comes in contact with the patient. Further, it is possessed of great vitality, and if protected from air may remain active for an unknown number of years. (*Aitken.*)

The stage of the disease at which the poison is first generated in the person of the sick is not accurately determined, but there cannot be the slightest doubt that, so soon as a case is diagnosed, precautionary measures should forthwith be adopted. If the patient is not at once removed to a hospital, he should be carefully isolated; those in attendance on him should if possible be protected by a previous attack of smallpox or by revaccination; and the same details with regard to the hygiene of the sick-room, disinfection, etc., should be observed as have already been insisted on in cases of typhus. The protection afforded by vaccination and revaccination, as well as other points of public importance, will be more conveniently discussed in the succeeding chapter. (See also Appendix I.)

6. *Scarlet Fever.*—Although this disease may attack persons of all ages, it specially attacks children between the third and fourth year; after the fifth year the chances of attack decline rapidly. The contagium, like that of smallpox, is exceedingly powerful and volatile, so that no susceptible person can remain in the same room for any length of time, or even in the same house, unless the patient is carefully isolated, without running great risk of contracting the disease. Moreover, the contagium is contained in everything which proceeds from the patient, but more especially in the cuticular scales given off in desquamation. These scales, laden with the specific poison, are conveyed by the currents of air to every part of the room, and may settle on clothing,

bedding, furniture, walls, etc. They preserve their virulence for an unknown period of time, and when disturbed are always liable to reproduce the disease. Thus, there are several instances recorded in which the fever has been contracted by sleeping in a room, which weeks previously had been occupied by a scarlet fever patient; and the fact that the poison adheres to articles of clothing is proved by instances in which the disease has been propagated by the clothing of pupils returning home from school. The cases already referred to in the chapter on water impurities are also of great interest in showing the absolute necessity of the utmost care and cleanliness to be observed on all occasions whether the attack is mild or severe. In the vast majority of cases, a previous attack confers permanent immunity from the disease.

The precautionary measures which are indicated by the above remarks are obvious; although it may be admitted that it is impossible to carry them out efficiently in the crowded homes of the poorer classes. But even in homes where no difficulty should be experienced, the necessary isolation and disinfection are too often grossly neglected, either because they are irksome, or, if the case is slight, because they are considered to be needless. And this applies to other infectious diseases, as well as to scarlet fever. The following rules, therefore, which have been drawn up from the experience of Drs. Ballard and Budd as part of the preventive treatment of scarlet fever, are more or less applicable to the hygienic management of cases of smallpox and typhus, and, at the risk of subsequent repetition, they may fitly be quoted here in full:—

"(1.) Remove from the sick apartment all superfluous woollen or textile matters, such as carpets, curtains,

and anything of that nature which are known to be retentive of disease-germs.

"(2.) Measures of disinfection should be used as early and as thoroughly as possible. Carbolic acid in solution, or as carbolate of lime, is especially useful, to sprinkle on the floor, and with which all parts of the room may be washed prior to cleansing and lime-whiting; and all articles to be washed ought to be soaked first in a solution of carbolic acid.

"(3.) A basin charged with chloride or carbolate of lime, or some other convenient disinfectant, is to be kept constantly on the bed for the patient to spit into, and which must be emptied and replaced at regular intervals.

"(4.) A large vessel (a tub) containing water impregnated with Condy's fluid or carbolic acid solution should always stand in the room (or near by), for the reception of all bed and body linen on its removal from the person or contact with the patient.

"(5.) In place of using pocket-handkerchiefs, use small pieces of rag for wiping the mouth and nose, so that each piece, after being used, may be at once burned.

"(6.) Two basins, one containing Condy's fluid or carbolic solution, and another containing plain soft water, and a good supply of towels, must always be ready and convenient, so that the hands of nurses may be at once washed after they may have been soiled by specific excreta. The dresses of nurses and attendants should be of linen, or smooth washable material.

"(7.) Glasses, cups, and other vessels used by or about the patient, are to be scrupulously cleaned before being used by others.

"(8.) The discharges from the bowels and kidneys

are to be received, *on their very issue from the body*, into vessels charged with disinfectants.

"(9.) To prevent the minute particles of desquamation from flying off as impalpable powder, their power for evil must be destroyed *in situ*, by anointing the surface of the body (the scalp included) twice a day with olive oil. It may be slightly impregnated with camphor, which Dr. Budd considers sufficient, or carbolic acid. The process relieves the itching of the skin, and is very soothing to the patient. So soon as efflorescence is observed on the skin of the neck and arms (as early sometimes as the fourth day), which marks the first liberation of the germ-carriers of the specific disease poison, the employment of the oil is to begin, and ought to be continued until the patient is well enough to take a warm bath, in which the whole person (scalp included) is well scrubbed, carbolic acid soap (Calvert's or Macdougall's) being abundantly used during the process. These baths are to be repeated every second day until four have been taken, when, as far as the skin is concerned, the disinfection may be regarded as complete, although a further quarantine of a week may be advisable.

"(10.) The chamber in which the sick person has been must now be thoroughly washed out, using freely carbolic acid and soft or black soap (which may now be got combined for the purpose)." (Aitken's *Science and Practice of Medicine*, 6th edition.)

It is not too much to say that were it possible that these precautionary measures could be carried out in every instance, the disease would soon be stamped out altogether.

7. *Measles.*—This disease, like scarlet fever, is

eminently communicable. The contagium may be conveyed by *fomites*, or by means of the contaminated air of the sick-room. The disease attacks persons of all ages and of both sexes, but is much more frequent amongst children. The risk of infecting commences with the primary fever, and is greatest when the specific eruption is fully developed. As a rule, a patient who has once suffered from the disease is no longer liable to a second attack.

8. *Hooping-Cough.*—The susceptibility to this disease is so strong that few persons have passed the age of childhood without having contracted it. Moreover, the infecting distance of the contagium appears to be very considerable, inasmuch as domestic isolation is frequently found to be of little avail in preventing the disease from attacking other members of the family who have not been protected by a previous illness. That the contagium may likewise adhere to clothing, and may in this way propagate the disease, has been clearly proved by numerous instances.

Such being the mode of propagation of measles and hooping-cough, the precautionary measures which are indicated comprise,—isolation of the patient, if other members of the family have not been protected by a previous attack; careful attention to the hygiene of the sick-room; and disinfection of the clothing, bedding, etc. And here it may be pointed ont that the prevalence of these two diseases is in great measure attributable to the culpable neglect, arising from the popular belief, amounting almost to fatalism, that children must contract them some time, and that there is therefore little use in endeavouring to take any protective steps when either disease is epidemic. The consequence is

that the epidemic continues to spread so long as susceptible victims are to be found in the community, and only dies out for a time when almost all these have been attacked. How far the medical profession are to blame in allowing this popular delusion to retain its hold on the public mind, it would be difficult to say, but until they unite in striving to get rid of the listless apathy which it engenders, the prevalence of such epidemic diseases will continue to be an opprobium to sanitary science. Nor must it be forgotton that medical men, in the hurry of practice, do sometimes, though unwittingly, convey the contagium of an infectious disease from one patient to another. For example, instances are not at all uncommon in which scarlet fever has been propagated in this way, and the records of puerperal fever contain the histories of many painful cases which could never have occurred had greater care been taken to guard against such fatal mishaps.

With regard to other infectious diseases which are not so liable to spread in an epidemic form, little need be said. Diphtheria requires that the sputum and handkerchiefs or rags used to wipe the mouth of the patient should be disinfected or destroyed, and injunctions should be given to attendants not to bend over the patient so as to run the risk of inhaling the breath. Further, as there are good grounds for believing that the disease is sometimes propagated by impure water or defective sewerage, these should both be looked to and remedied.

In these remarks on the mode of propagation of infectious disease, it has been assumed throughout that the body of the diseased person is the soil in which the germs of the disease are multiplied; that these

germs, whatever be their nature, are given off by the patient, and may contaminate the air or drinking-water, or may adhere to clothing, bedding, furniture, or walls of a room; that, either directly or after remaining dormant for an unknown period of time, they may infect other persons; and that, by adopting suitable measures, they can be destroyed altogether, or rendered inoperative to a large extent. So far also these remarks have had special reference to the precautionary measures which form a part of personal and domestic hygiene, and which fall under the control and regulation of the private medical attendant. The general proceedings which should be carried out under the advice of a health officer in places attacked or threatened by epidemic disease, have been summarised by Dr. Aitken from a memorandum drawn up by Mr. Simon as follows (see Aitken's *Science and Practice of Medicine*, 6th edit.):—

"1. Wherever there is prevalence or threatening of cholera, smallpox, diphtheria, typhus, or any other epidemic disease, it is of more than common importance that the powers conferred by the Nuisance Removal Acts, and by various other laws for the protection of the public health" (see Appendix I.), "be vigorously, but at the same time judiciously exercised by those in whom they are vested; and with regard to armies, that the instructions relative to the guidance of the medical officer in sanitary matters, contained in the army regulations, be duly carried out on the principle that the executive should act under authority, in order to carry out the required measures efficiently.

"2. If the danger be considerable, it will be expedient that the local authorities in civil life, and the commanding officers of armies, brigades, divisions, and

regiments, in military life, avail themselves as soon as possible of the medical advice within their reach, in taking measures of prevention and protection against the spread of epidemic influences.

"3. Measures of precaution for prevention and protection are equally proper for all classes of society, civil and military. But it is chiefly with regard to the poorer civil population—therefore chiefly in the courts and alleys of towns, and at the labourers' cottages of country districts—that local authorities are called upon to exercise the utmost vigilance, and to proffer information and advice. Common lodging-houses, and houses which are sublet in several small holdings, always require particular attention.

"4. Wherever there is accumulation, stink, or soakage of house-refuse, or of other decaying animal or vegetable matter, the nuisance should as promptly as possible be abated, and precaution should be taken not to let it recur. Especially all complaints which refer to sewers and drains, or to foul ditches and ponding of drainage, or to neglect of scavening, should receive immediate attention. The trapping of house drains and sinks, and the state of cesspools and middens, should be carefully seen to. In slaughter-houses, and other places where beasts are kept, strict cleanliness should be enforced.

"5. In order to guard against the harm which sometimes arises from disturbing heaps of offensive matter, it is often necessary to combine the use of chemical disinfectants with such means as are taken for the removal of filth; and in cases where removal is for the time impossible or inexpedient, the filth should always be disinfected. Disinfection is likewise desirable for

unpaved earth close to dwellings, if it be sodden with slops and filth. Generally, where cholera or typhoid fever is in a house or barrack, hospital or hut, the privies especially require to be disinfected.

"6. Sources of water-supply should be carefully and efficiently examined. Those of them which are in any way tainted by animal or vegetable refuse,—above all, those into which there is any leakage or filtration from sewers, drains, cesspools, or foul ditches,—ought no longer to be drunk from. Where the disease is cholera, diarrhœa, or typhoid fever, it is especially essential that no foul water be drunk.

"7. The washing and lime-whiting of uncleanly premises (houses, huts, hospitals, barrack guard-rooms, and the like), especially of such as are densely or multifariously occupied, should be pressed with all practicable despatch.

"8. Overcrowding should be prevented. Especially where disease has begun, the sick-room should, as far as possible, be free from persons who are not of use or comfort to the patient.

"9. Ample ventilation should be enforced. Window-frames should be seen to,—(1.) That they may be made to open, if not so made; and (2.) That they be kept sufficiently open. Especially where any kind of specific disease, communicable by infection of the air, has begun, it is essential, both for patients and for persons who are about them, that the sick-room and the sick-house or hospital be constantly and efficiently traversed by streams of fresh air. This is especially necessary at night, and steps should be taken to ensure efficient ventilation, even at some real or imaginary expense of comfort.

"10. The cleanest domestic habits should be enjoined. Refuse matters should never be suffered to remain or to linger within the dwelling, hospital, barrack-room, or hut. Such refuse must at once be removed, and at once disposed of, or cast into the receptacle provided for it. All things or utensils which have to be disinfected or cleansed should always be disinfected or cleansed without delay.

"11. With regard to material substances discharged or separated from the bodies of the sick, special precautions of cleanliness and disinfection are necessary. Among discharges or substances separated from the body which it is proper to treat as capable of communicating disease, are those which come, in cases of small-pox, from the affected skin; in cases of cholera and typhoid fever, from the intestinal canal; in cases of diphtheria and scarlatina maligna, from the nose and throat, and the exhalations from the skin and the lungs saturating clothes; likewise, in cases of eruptive fevers, measles, scarlatina, rötheln, typhus, and the like, the general exhalations of the sick, and especially so of the convalescing, probably in connection with the desquamation of the skin. The caution which is necessary with regard to such matters must of course extend to whatever may be imbued with them; so that bedding, clothing, towels, and other articles which have been in use by the sick, do not become sources of mischief, either in the house to which they belong, or in houses to which they are conveyed. Moreover, in typhoid fever and cholera, the evacuations should be regarded as capable of communicating a similarly specific and infectious property to any night-soil with which they may be mingled in privies, drains, or cesspools. This danger

of multiplying the sources of communicating disease must be guarded against by the chemical destruction, decomposition, or disinfection, of all the intestinal evacuations as soon as they are passed from the bowels, and certainly before they are thrown away, and so let loose upon the world. Above all, they must never be cast where they can run or soak into sources of drinking water.

"12. All reasonable care should be taken not to disseminate disease by the unnecessary association of persons suffering from the specific communicable diseases, either with healthy persons, or in wards of hospitals where patients suffering with other diseases are being treated. This care is requisite not only with regard to the sick-house, ward, hospital, or ship, but likewise with regard to day schools, places of public resort, courts of justice, and other places where members of many different households are accustomed to meet.

"13. Where dangerous conditions of residence cannot be promptly remedied, it will be best that the inmates, while unattacked by disease, remove to some safer lodging. If disease begins in houses where the sick person cannot be rightly circumstanced and tended, medical advice ought to decide on the propriety or fitness of removing him to an infirmary or hospital. In extreme cases, special infirmaries may become necessary for the sick, or special houses of refuge for the endangered.

"14. The questions of quarantine ought to be decided by the circumstances of the special case, the preceding principles being kept in view.

"15. Privation, as predisposing to disease, may require special measures of relief.

"16. In certain cases special medical arrangements are necessary. For instance, as cholera in this country almost always begins somewhat gradually in the comparatively tractable form of what is called 'premonitory diarrhœa,' it is essential that, where cholera is epidemic, arrangements should be made for affording medical relief without delay to persons attacked even slightly with looseness of the bowels. So, again, where smallpox is the prevailing disease, it is essential that all unvaccinated persons (unless they previously have had smallpox) should very promptly be vaccinated; and re-vaccination should also be offered, both to persons above puberty who have not been vaccinated since childhood, and to younger persons whose marks of vaccination are unsatisfactory.

"17. It is always to be desired that the people should, as far as possible, know what real precautions they can take against the disease which threatens them, what vigilance is needful with regard to its early symptoms, and what, if any, special arrangements have been made for giving medical assistance within the district. Especially in the case of smallpox or of cholera such information ought to be spread abroad by means of printed bills or placards. In any case where danger is great, house to house visitation, or personal inspection of all by discreet and competent persons, may be of the utmost service, both in quieting unreasonable alarm, and in leading or assisting the less educated and the destitute parts of the population to do what is needful for safety.

"18. These memoranda relate to occasions of emergency. The measures suggested must be regarded as of an extemporaneous kind. Permanent provisions for

securing public health have not been in express terms insisted on. In proportion as a district or number of individuals, such as an army or regiment, is habitually well cared for by its sanitary authorities, the more formidable emergencies of epidemic disease are not likely to arise."

SECTION II.—DISINFECTANTS.

In the wide sense of the word, the term disinfectant may be defined as any agent which oxidises or renders innocuous decomposing organic matters and offensive gases, which arrests decomposition, or which prevents the spread of infectious diseases by destroying their specific contagia. The term, therefore, includes any agent which possesses deodorising, antiseptic, or fixative properties.

Without entering into any discussion on the *modus operandi* of disinfectants generally (because the subject is still under dispute), it will be convenient for practical purposes to enumerate and describe the most useful amongst them *seriatim* and without any attempt at classification.

1. *Heat and Cold.*—While extreme cold prevents putrefactive change, and therefore acts as an antiseptic, extreme heat is destructive of all organic matter, and in this respect it is the most efficacious, as it is the most ancient, of all disinfectants. But even a temperature much below that of actual combustion is found to be sufficiently powerful, if continued for any length of time, to kill animal or vegetable germs, and to render inert any contagious matter. Thus, the late Dr. Henry proved experimentally that the vaccine virus was de-

prived of the power of reproduction when exposed for three hours to a temperature of 140° Fahr., while a temperature of 120° failed to produce this effect. As a result of these and other experiments, he was the first to recommend the employment of the hot-air chamber to disinfect clothing, bedding, and the like; and experience has proved that, when conducted with care, the plan is highly successful.

2. *Charcoal* is a powerful deodorant, but there is no evidence to show that it has any effect in destroying specific disease-germs. It oxidises offensive organic effluvia, and is therefore very useful in purifying sewer-gases or other filth-emanations.

3. *Chlorine* decomposes sulphuretted hydrogen and ammonium sulphide more certainly than any other gas, and is an energetic destroyer of all organic substances prone to decay. It is especially valuable in purifying rooms which have been occupied by persons suffering from infectious diseases, but it is doubtful whether it can be of much service in the hygiene of the sick-room itself, because, even when largely diluted, it is very irritating to the lungs. It is given off in small quantities by chloride of lime moistened with water, or when employed in scrubbing out the floor. It may also be obtained by adding a little muriatic acid gradually to a wine-glassful of Condy's fluid, or to crystals of potassium chlorate. When required in large quantity for the disinfection of empty rooms, it is most rapidly obtained in one of the following ways:—(1.) To equal parts of common salt and binoxide of manganese add two parts of water, and about the same amount of strong sulphuric acid. (2.) To one part of powdered binoxide of manganese add four parts by weight of strong muri-

atic acid. (3.) To three parts of bleaching powder add one part of strong sulphuric acid. In any case, the quantities required will depend upon the size of the room.

4. *Nitrous Acid.*—Nitrous fumes are obtained by adding strong nitric acid, diluted with a little water, to copper filings. The power of oxidation of organic matter possessed by nitrous acid is very great, and no disinfectant will more readily remove the offensive smell of the dead-house. The fumes, however, are exceedingly irritating and dangerous,—so much so, that this process of disinfection is only suitable for empty rooms, and under skilled superintendence.

5. *Iodine,* though less useful than chlorine, has been recommended as a substitute by Dr. Richardson and others. It is a powerful antiseptic, and may be diffused through the air of a room by placing a small quantity of the substance on a warm plate.

6. *Bromine.*—The vapour of bromine can be obtained by exposing a solution of bromine in potassium bromide in open dishes. It was largely used as an atmospheric disinfectant during the American war, but has not found much favour in this country,

7. *Sulphurous Acid Gas.*—This is exceedingly useful for disinfecting empty rooms. It is obtained by burning sulphur in an earthenware pipkin or other vessel that will not readily crack. It decomposes sulphuretted hydrogen, and as it combines with ammonia, it deodorises or destroys stinking alkaloids, and, probably, disease-germs.

8. *Carbolic Acid.*—This is one of the most popular disinfectants, and is especially valuable on account of its highly antiseptic properties. In its pure state, it is a white crystalline solid, which in a diluted form has been

found to be of immense service in preventing putrefactive change in surgical wounds. The commercial article is a thin, tarry fluid, possesssing a somewhat offensive odour. It is highly poisonous, and has already been productive of several fatal accidents, on account of its having been mistaken for porter or other fluids. For this reason, the carbolic acid powder is safer as a domestic disinfectant. It can be employed in scrubbing out floors, in steeping infected clothing, and in vessels for receiving the excreta. It is also very useful in disinfecting urinals, latrines, water-closets, stables, midden-heaps, etc. In whatever form, the acid is destructive of the low forms of animal and vegetable life, and arrests or prevents all kinds of putrefactive change.

9. *Condy's Fluid*, red and green, consists of a solution of potassium permanganate. It is essentially an oxidising agent, and as it is odourless it is very valuable in the sick-room.

10. *Chloride of Aluminium*, or "*Chloralum*," is a powerful disinfectant, and possesses the great advantages of being non-poisonous, inodorous, and very cheap. Professor Wanklyn says that "for removing fœtor and effluvia, it is better and more available than any agent with which I am acquainted. In this respect it is incomparably superior to chloride of lime." Dr. Dougall, after a series of carefully-conducted experiments, likewise maintains that it arrests putrefactive change, and prevents the appearance of animalculæ to a greater extent than any of the commonly employed disinfectants. Not being volatile, it cannot be regarded as an aerial disinfectant, but it is exceedingly useful in washing infected clothing, or as a scouring material for cleansing rooms. It is also an excellent sewage-deodorant

11. *Chloride of Lime* is useful, as already stated, in supplying chlorine gas and for cleansing purposes.

12. *M'Dougall's powder* consists of carbonate of lime and magnesium sulphite. Like Calvert's carbolic acid powder, it may be employed very advantageously for cleansing purposes, and for the disinfection of masses of putrescent matter, sewage, or excreta.

13. *Sulphate of Copper* has been recommended by Dr. Dougall as possessing antiseptic properties equal to those of chloralum; but it is not so suitable on account of its price and poisonous nature.

14. *Chloride of Zinc.*—"Burnett's solution" consists of 25 grains of this salt to every fluid drachm. It destroys ammoniacal compounds and organic matter. When used, it should be diluted with eight times its bulk of water.

15. *Ferrous Sulphate* or *Copperas* has been largely used for disinfecting heaps of manure and sewage. It has also been recommended by Pettenkofer to be added to cholera evacuations for the purpose of destroying the contagium; but it does not appear to have been attended with any good results.

Other sewage disinfectants have already been described in the chapter on the Purification of Sewage.

16. *Cooper's Salts,* already referred to in a previous chapter, have been highly recommended as street and sewer disinfectants.

17. *Potassium Bichromate* has been extolled by Dr. Angus Smith, and chromic acid by Dr. Dougall, as being powerful antiseptics, but it is doubtful whether their price will ever permit of their being largely employed.

Although the names of other agents could be added to this list, it embraces all the more useful disinfectants,

and several which, while they are useful, are not so common. Probably the most reliable and popular amongst them may be enumerated as follows:—heat, chlorine, sulphurous acid, nitrous acid, carbolic acid, Condy's fluid, chloralum, ferrous sulphate, chloride of zinc, chloride of lime, M'Dougall's and Calvert's powders, and charcoal.

Section III.—Practical Disinfection.

1. *Hygiene of the Sick-room.*—In all cases of highly-infectious disease, the first duty to be attended to is the enforcement of a strict domestic quarantine by isolation of the patient whenever it is possible; the next point is to make certain that the room is well lighted and sufficiently ventilated by means of open windows, and fires if necessary; and the third point is to require the instant removal of all extraneous furniture, such as carpets, curtains, and the like. The attendant on the patient should receive strict and precise injunctions, not only with regard to the nursing of the patient, but also with regard to the maintenance of the utmost cleanliness in the room; the disinfection of excreta, slops, soiled linen, etc., and their immediate removal afterwards; and other points of detail depending upon the special nature of the disease and the circumstances of the patient.

Although aerial disinfectants are regarded by some as of doubtful efficacy in the sick-room, they are deemed to be useful or expedient by many; and, when properly selected and managed, it may be said, at all events, that they do not do any harm, if they are not productive of much good. The great danger is, that when employed

without due precaution, they may only serve to disguise the signs of insufficient ventilation, and in this way conduce to inattention as regards this most essential point. If they are employed—and many believe that their use is imperative in some diseases—they should not be irritating to the patient. Chlorine gas slowly evolved, or carbolic acid vapour, are the agents which commend themselves to most. The vaporiser introduced by Savory and Moore, or Siegle's spray-producer, is each an excellent instrument for distributing the carbolic acid vapour, or it may be distributed to the desired extent by placing a little of the acid in wet sand in flat dishes, or by using the powder as a cleansing agent in scrubbing out the floor daily. Hanging rags steeped in disinfectant solutions about the room is not to be commended, but a sheet moistened with a strong solution of chloralum, carbolic acid, or Condy's fluid, and suspended outside the door of the room, is very necessary to complete the isolation of the patient. The infected clothing, etc., should be received into a tub containing chloralum or carbolic acid, and the ejecta, etc., should be instantly covered with Burnett's solution, copperas, chloralum, or carbolic acid. Care must also be taken, in using different disinfectants, that they do not counteract each other; for example, carbolic acid decomposes Condy's fluid. Further, as has already been pointed out, the inunction of the body of the patient, in certain of the exanthematous infectious diseases, with camphorated oil, or a weak solution of glycerine and carbolic acid, followed by disinfecting baths during convalescence, appears to be attended with very good results.

2. *Disinfection of Empty Rooms and Uninhabited Places.*—After a case of infectious disease, the room

should be thoroughly cleansed and disinfected. The furniture should be washed with a strong solution of chloralum (three or four ounces to the gallon of water), or with carbolic acid soap, and the room, as far as possible, emptied. Afterwards the floor and wood-work should also be thoroughly washed with carbolic acid soap, and the paper, first moistened with chloralum or carbolic acid solution, should be removed. Then, after closing doors, windows, and other openings, chlorine, sulphurous acid, or nitrous acid gas, should be generated in large quantities in the manner already described, and the room kept closed for several hours. After this, the door and windows should be thrown open, and in a few days the ceiling should be washed with quick lime and whitened, and the walls re-papered.

3. *Disinfection of Clothing, Bedding, etc.*—Any material of this description which cannot be injured by being washed, should be steeped in a solution of chloralum or carbolic acid, and boiled. If Condy's fluid be used, the material should merely be immersed, and afterwards rinsed out in cold water, otherwise the solution will stain. In all cases, however, when it can be carried out, the clothing, bedding, etc., are best disinfected by being exposed for an hour at least to a dry heat of about 240° or 250° Fahr., and for this purpose every town of any dimensions should be provided with a hot-air disinfecting chamber for public use. Such a chamber is built of brick, and is heated by a coil of hot-air pipes lying underneath a perforated grating, and communicating with a furnace which opens outside.

The hair of infected mattresses should be teased out, exposed to the air, and, whenever possible, should be disinfected in the hot-air chamber. Rags and other

articles which can be spared should be destroyed by fire. When clothing cannot be disinfected by heat, Dr. Ransome has proposed that the different articles should be placed, layer on layer, in a box with hot sand or bricks placed at the bottom, and sprinkled over with carbolic acid.

4. *Disinfection of Water-Closets, Urinals, Sinks, etc.*—In any district where an epidemic prevails or is threatening, disinfection of all water-closets, etc., should be carried on systematically, either with solutions of chloralum, carbolic acid, copperas, or Burnett's fluid. Cooper's salts should be used for the streets, lanes, and open courts. Any manure-heaps or other accumulations of filth, which it is inexpedient to disturb or impossible to remove, should be covered with powdered vegetable charcoal to the depth of two or three inches, or with a layer of fresh dry earth, or with freshly-burnt lime, if charcoal cannot be obtained. Cess-pits and midden-heaps may be disinfected with solutions of copperas (3 lbs. to the gallon of water), or with chloralum (1 lb. to the gallon of water). It need hardly be said, however, that in a town or district well looked after by the sanitary authorities, no such filth-accumulations would be allowed to take place at any time.

5. *Disinfection of the Dead Body.*—When a patient dies of a highly infectious disease, such as smallpox or scarlatina maligna, the body should be washed with a very strong solution of carbolic acid or chloralum, and placed in the coffin as soon as possible, disinfectants being again freely used, and the lid screwed down. The burial should take place without delay; or in crowded districts, and in towns where a mortuary is provided, the dead body should be at once removed

thither. The linen worn by the patient at death, if not buried with the body, should be destroyed by fire.

It may be urged that many of these directions are needlessly minute, and that, in fact, they cannot possibly be carried out in perhaps the great majority of cases. In answer to such objections, let it be said, once and for all, that no labour is wasted which aims at preventing the spread of disease, even though it be often attended with failure; and that, however limited be the means or opportunity of carrying out preventive or precautionary measures, such means and such opportunity should always be used, so as to be productive of the best possible results under the circumstances.

CHAPTER XIV.

THE DUTIES OF MEDICAL OFFICERS OF HEALTH.

By section 10 of "The Public Health Act, 1872," it is enacted that it shall be the duty of every urban and of every rural sanitary authority, throughout England and Wales, to appoint from time to time a legally qualified medical officer or officers of health for the efficient execution of the purposes of the Sanitary Acts. In the case of rural sanitary districts, such officers may be the district medical officers of Unions, who are to a certain extent under the control of the Local Government Board; but in the case of urban sanitary districts, those medical officers of health will alone be subject to the control of the Local Government Board whose salaries will be partly paid out of monies voted by Parliament. Such urban sanitary authorities, therefore, who do not choose to receive assistance from the public purse in the payment of their health officers, may appoint or dismiss such officers without the consent of the Local Government Board, and may issue such regulations for their guidance as they may from time to time determine. In either case, however, the duties of the medical officer of health will, in great measure, be identical as regards the main points; and hence the following rules, which have recently been issued by the Local Government Board for the guidance of urban medical officers of health whose appointment will be

made subject to the approval of the Board, may be considered as more or less applicable to all health officers. By an order, dated 11th November 1872, these duties are thus defined:—

"The following shall be the duties of the medical officer of health in respect of the district for which he is appointed; or, if he shall be appointed for more than one district, then in respect of each of such districts.

"1. He shall inform himself, as far as practicable, respecting all influences affecting or threatening to affect injuriously the public health within the district.

"2. He shall inquire into and ascertain by such means as are at his disposal the causes, origin, and distribution of diseases within the district, and ascertain to what extent the same have depended on conditions capable of removal or mitigation.

"3. He shall, by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed of the conditions injurious to health existing therein.

"4. He shall be prepared to advise the sanitary authority on all matters affecting the health of the district, and on all sanitary points involved in the action of the sanitary authority or authorities; and in cases requiring it, he shall certify, for the guidance of the sanitary authority or of the justices, as to any matter in respect of which the certificate of a medical officer of health or a medical practitioner is required as the basis or in aid of sanitary action.

"5. He shall advise the sanitary authority on any question relating to health involved in the framing and subsequent working of such bye-laws and regulations as they may have power to make.

"6. On receiving information of the outbreak of any contagious, infectious, or epidemic disease of a dangerous character within the district, he shall visit the spot without delay and inquire into the causes and circumstances of such outbreak, and advise the persons competent to act as to the measures which may appear to him to be required to prevent the extension of the disease, and, so far as he may be lawfully authorised, assist in the execution of the same.

"7. On receiving information from the inspector of nuisances

that his intervention is required in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall, as early as practicable, take such steps authorised by the statutes in that behalf as the circumstances of the case may justify and require.

"8. In any case in which it may appear to him to be necessary or advisable, or in which he shall be so directed by the sanitary authority, he shall himself inspect and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, or flour, exposed for sale, or deposited for the purpose of sale, or of preparation for sale, and intended for the food of man, which is deemed to be diseased, or unsound, or unwholesome, or unfit for the food of man; and if he find that such animal or article is diseased, or unsound, or unwholesome, or unfit for the food of man, he shall give such directions as may be necessary for causing the same to be seized, taken, and carried away, in order to be dealt with by a justice according to the provisions of the statutes applicable to the case.

"9. He shall perform all the duties imposed upon him by any bye-laws and regulations of the sanitary authority, duly confirmed, in respect of any matter affecting the public health, and touching which they are authorised to frame bye-laws and regulations.

"10. He shall inquire into any offensive process of trade carried on within the district, and report on the appropriate means for the prevention of any nuisance or injury to health therefrom.

"11. He shall attend at the office of the sanitary authority or at some other appointed place, at such stated times as they may direct.

"12. He shall from time to time report, in writing, to the sanitary authority, his proceedings and the measures which may require to be adopted for the improvement or protection of the public health in the district. He shall in like manner report with respect to the sickness and mortality within the district, so far as he has been enabled to ascertain the same.

"13. He shall keep a book or books, to be provided by the sanitary authority, in which he shall make an entry of his visits, and notes of his observations and instructions thereon, and also the date and nature of applications made to him, the date and result of the action taken thereon, and of any action taken on previous reports, and shall produce such book or books, whenever required, to the sanitary authority.

"14. He shall also prepare an annual report, to be made at the end of December in each year, comprising tabular statements of the sickness and mortality within the district, classified according to diseases, ages, and localities, and a summary of the action taken during the year for the preventing the spread of disease. The report shall also contain an account of the proceedings in which he has taken part or advised under the Sanitary Acts, so far as such proceedings relate to conditions dangerous or injurious to health, and also an account of the supervision exercised by him, or on his advice, for sanitary purposes, over places and houses that the sanitary authority has power to regulate, with the nature and results of any proceedings which may have been so required and taken in respect of the same during the year. It shall also record the action taken by him, or on his advice, during the year, in regard to offensive trades, bakehouses, and workshops.

"15. He shall give immediate information to the Local Government Board of any outbreak of dangerous epidemic disease within the district, and shall transmit to the board, on forms to be provided by them, a quarterly return of the sickness and deaths within the district, and also a copy of each annual and of any special report.

"16. In matters not specifically provided for in this order, he shall observe and execute the instructions of the Local Government Board on the duties of Medical Officers of Health, and all the lawful orders and directions of the sanitary authority applicable to his office.

"17. Whenever the Diseases Prevention Act of 1855 is in force within the district, he shall observe the directions and regulations issued under that Act by the Local Government Board, so far as the same relate to or concern his office."

For the efficient and conscientious discharge of these duties, it is evident that a medical officer of health must make himself thoroughly acquainted with the fundamental principles of public and practical hygiene, with the general and local circumstances which may affect the health of the population in his district, and with the various Sanitary Acts which more immediately concern his office. So much is left to his discretionary

power in certifying as to what is or is not injurious to the public health, that he cannot but feel the grave responsibility which will devolve upon him, if, through ignorance or neglect on the one hand, or through mistaken zeal and want of tact on the other, he fails to carry out his duties honestly, judiciously, and to the best of his ability.

As there is no doubt that considerable difficulty will be experienced at the outset by most health officers in regard to the mode in which their duties should be carried out, the suggestions and information, gathered from various sources and summarised under the following sections, may, it is hoped, prove of some service:—

Section I.—Natural Conditions affecting the Health of the Population contained in the District.

These comprise the geological and topographical characteristics of the district, the water-supply, and the climate.

1. *Geological Conditions.*—Official information as regards these may be obtained from the Ordnance maps and the special sections published by the Surveyor-General; while fuller details could be readily collected from local sources. In most districts there will generally be found some one who has made the geology of the locality a special study.

2. *Topographical Conditions.*—These relate to the situation of the various parts of the town or district, whether low-lying, elevated, or sloping.

3. *Water-supply.*—The quantity and quality of the obtainable water-supply in a district will depend very

much on the two previous sets of conditions. So also will the nature of the subsoil and the facilities for drainage and sewerage. All this, however, has been fully explained in previous parts of this work. (See Chapters VI., VII., and XII.)

4. *Climate.*—Under this heading are comprised the meteorological conditions of the district, such as, the daily temperature and rainfall, the force and direction of winds, the barometric pressure, the degree of humidity, and the amount of ozone. In most large towns, these observations are already being carefully recorded, and where this is the case, the health officer should endeavour to obtain, through the sanitary authority, the record of the observations weekly. In districts where no such observations are made, he should, if possible, procure the necessary instruments from the sanitary authority, and arrange that accurate observations be made daily, after the manner and at the hours stated in the reports published from day to day in the *Times* newspaper. The short chapter on meteorology in Dr. Parkes' *Manual of Practical Hygiene* or Buchan's *Handbook of Meteorology* will give all the needful information.

As the science of climatology is yet in its infancy, health officers here and there throughout the country would render immense service to sanitary science if they would contribute to this important branch of public hygiene either by undertaking chemical analyses as Dr. Angus Smith has done (see Chapters III. and V.) or, as Dr. Ballard, by comparing the sick-rate and death-rate with seasonal variations. (See *Eleventh Report of the Medical Officer of the Privy Council.*) But whether such voluntary services be imparted or

not, it is essential for the fair and faithful discharge of the duties of a health officer, that he should take cognisance of meteorological fluctuations, because they constitute most important factors of health or disease in every district.

Section II.—Artificial Conditions affecting the Health of the Population contained in the District; such as—

1. *Habitations of the People.*—So far as possible the sanitary condition of every house in the district should be inquired into. Of course, the health officer himself could not undertake such a laborious inquiry, but it could be easily and efficiently carried out by the temporary appointment of one or more competent persons, who would be paid by the sanitary authority and directed by the health officer. With regard to this part of the subject, the remarks of Mr. Dyke, the accomplished health officer of Merthyr Tydfil, are well worth quoting:—"Such an inquiry was made in Merthyr in the autumn of 1866; nearly 10,000 houses were examined and reported on by four intelligent persons; five weeks were occupied in the examination and report, the cost to the local board being £25. This inquiry embraced the following:—The name of the street, number of each house, names of occupier and owner, number of family and lodgers; the ventilation, how it was secured, whether by back doors, or by windows whose upper sashes could be fully let down; the number of privies or of water-closets, and the state of these; the water-supply, whence derived, and the state of any back premises, noticing particularly whether any animals or

poultry were kept. When these returns were completed they were tabulated by the medical officer, for *each street* in *each district,* and the results summed up. The usefulness of these returns has been continuous. They now afford stand-points of reference whence to mark the improvements made, and to note the dark spots that call for amendment; by referring to this 'Dictionary of Habitations,' the state of each house is at once apparent, and upon the occurrence therein of any case of disease, such as, *e.g.,* enteric fever or phthisis, the exciting cause, whether excrementitious exhalations or dampness of foundations, may be found." (*Brit. Med. Journal,* November 16, 1872.)

An inquiry of this description, if sanctioned by the sanitary authority, would be of immense service to the health officer of every district, and would cost but little. As far as possible, it should embrace full details concerning lodging-houses and the crowded and dilapidated dwellings of the poorer classes, with regard to cubic space, means of ventilation, refuse-removal, etc. (See Chapter VIII. and Appendix I.)

2. *Water-supply.*—In districts where the water-supply is public, the health officer should make himself acquainted with the quality of the water, amount per head, and the risks of pollution. The localities of wells should also be carefully examined and noted. (See Chapter VI. and Appendix I.)

3. *Drainage, Sewerage, Scavenging, etc.*—Full information with regard to these conditions would be obtained from the borough engineer or town surveyor. In country districts, all open ditches and filthy stagnant pools in proximity to dwellings should receive particular attention. (See Chapters X., XI., XII., and Appendix I.)

4. *Factories, Workshops, Bakehouses, Public Institutions, Slaughter-houses, etc.*—These should be carefully examined with reference to overcrowding, air-impurities, and the production of nuisances generally. (See Chapter III. and Appendix I.) Factories already under Government inspection would not of course be subject to the supervision of the health officer, except in so far as they prove to be a nuisance or injurious to the health of the neighbouring inhabitants.

Section III.—Vital Statistics.

Having thus obtained a full knowledge of the natural and artificial conditions which affect the health of the population, the health officer should next make himself acquainted with the vital statistics of his district. By referring to the more recent quarterly and annual reports of the Registrar-General, and the half-yearly abstracts of the boards of guardians, he will obtain all the statistical data representing the vital history of the district for the past few years, as indicated by the number of the population, its rate of increase, the birth-rate, the marriage-rate, the rate of mortality, the prevalency of epidemic or other fatal diseases, the death-rate at different ages, the amount of pauperism, etc. From the last census returns, again, he would obtain much useful information as regards the areas, houses, and population, and the ages, civil condition, occupation, and birthplaces of the people. Such a retrospect, it need hardly be said, would be especially valuable in enabling him to arrive at reliable conclusions concerning the effects of sanitary improvements and the more rigid enforcement of the various Sanitary Acts within his

district. It would form a sound basis of local statistical knowledge to start with, and by pursuing the same course with regard to the registration and pauper returns, the more important of which might be obtained weekly, the health officer would be in a position at all times to inform the sanitary authority concerning the prevalence of infectious and preventable diseases, and advise as to what steps should be taken. But as the death-rate gives no sufficient indication of the sick-rate, he should also put himself in communication with poor-law medical officers, relieving officers, the medical officers of public institutions, and, as far as possible without making himself officious, with the other medical men in the district.

In order to obtain weekly returns of the births, deaths, etc., application should be made by the sanitary authority to the Registrar-General, and with his consent the district registrar would fill in the returns, and forward them to the health officer every Monday, the sanitary authority remunerating him for his trouble, and providing him with blank forms. According to Mr. Dyke, the cost of these weekly returns for Merthyr Tydfil does not exceed £8 annually, although the population amounts to 50,000, and the average numbers of births and deaths per annum to 2000 and 1400 respectively. The following is a copy of the form used :—

Form of Weekly Return to be made by Subdistrict Registrars.

District of Merthyr Tydfil. Subdistrict of ——. Return of Number of Births and Deaths during the week ending Saturday, the —— day of —— 18—. Births : Legitimate, M., —, F., — = — ; Illegitimate, M., —, F., —, = — ; total, ——. Deaths : Male, —, Female, —, = — ; total, ——.

(The Medical Officer will be glad to have this return every Monday.)

Particulars of Deaths registered in the week: Register No.; when died; residence; names; sex; age; occupation; causes of death (1, 2); duration of diseases (1, 2); certified or not, or inquest.

By means of the information supplied by weekly returns of this description, the health officer would be enabled to tabulate all the mortality statistics in such a manner as would show the connection between the death-rate and the sanitary or unsanitary conditions of various parts of his district, the prevalency of any particular diseases in certain areas, and so on. "My habit," says Mr. Dyke in the paper already referred to, "has been to set down under each division of the district the details of the mortality of each week; thus, week ending ——, male or female, cause of death, age at death. Summing up these each quarter, I obtain the numbers of males and females, the numbers under and over five years, the causes of death, and the total of years lived by the whole number. This total, divided by the whole number, yields the average age at death. From this district ledger (as it were) I post all cases into the several headings of the general mortality table, placing opposite the name of each disease, under one of the several ages, the score of the particular death of the male or female. The sum of the deaths from each cause, the sums of the deaths from each class of disease, and the total of deaths, would be brought out in the columns on the extreme right; while the base-line of each column would show the mortality at each age."

Other statistics as regards the number of marriages, and the number of children successfully vaccinated, might also be obtained from the district registrar every

quarter; and, as already stated, the half-yearly abstracts of the boards of guardians would be especially valuable in judging of the general prosperity or otherwise of the community, as influenced by the rate of wages and the price of food.

In drawing conclusions from statistical data, great care must be taken to guard against fallacies. For example, the death-rate of the whole of a district may be comparatively low by reason of the preponderance of adult or selected lives, while the sanitary conditions are far from satisfactory; or, again, the total death-rate may still not be above the average, while the death-rate in certain portions of the district may be excessively high. Generally speaking, the effects of sanitary improvements and precautionary measures are best indicated by a lowered death-rate amongst persons of all ages, from infectious diseases, diarrhœa, and phthisis, and, amongst children under five years of age, from all causes. Indeed, it may be said that the death-rate of children under five years of age is in many places a far more reliable criterion of the sanitary conditions affecting the health of a community than the total average mortality-rate, even although every allowance is made for neglect, maltreatment, deficiency of food, and exposure. Nor, again, in drawing conclusions from mortality returns, must the influence of social causes of disease be forgotten, for the effects of intemperance, immorality, and injudicious marriages, especially amongst the lower classes in all our large towns, can scarcely be over-estimated. (See Chapter I.) Thus, Drs. Parkes and Sanderson, in their reports on the sanitary condition of Liverpool, after describing numerous instances that came under their own obser-

vation, write—"It is not surprising that our informants, who, as we stated, have the fullest information on the habits of the people, say decidedly 'that drink and immorality are the two great causes of the mortality.'"

But without entering farther into this part of the subject, which admits of endless digression, the following statistical data will serve, more or less fully, to illustrate the previous remarks. They are given in the reports on the sanitary condition of Liverpool just referred to—reports, by the way, which should be carefully perused by every newly-appointed health officer of an urban district:—The mean annual mortality of Liverpool during the decennium 1861-1870 calculated upon the mean annual population (1861-1871) was 38·59 per 1000 inhabitants. In 1865 it was 44·0 per 1000 when an epidemic of typhus prevailed, and in 1866 it rose as high as 50·7 per 1000 during the cholera epidemic. The ordinary annual mortality in years not marked by any epidemic was about 35 per 1000 inhabitants. In the same ten years the mean annual mortality per 1000 of population, calculated on the mean annual population, was as follows in the undermentioned seaport and manufacturing towns:—

Bristol	22·5
London	24·3
Hull	24·9
Bradford	26·2
Sheffield	27·2
Leeds	28·0
Manchester	30·2

Exclusive of the dangers arising from imported infectious diseases, to which Liverpool is undoubtedly exposed, and by which the population in certain years has greatly suffered, it became apparent that the exces-

sive mortality over other large towns was due to local causes. That it was not due to climatic influences was proved by the comparative low mortality-rate of certain districts, and by the difference between the death-rate of certain healthy streets, as compared with that of certain other streets which were selected as fairly representing the homes of the poorer classes. This is clearly shown in the following table :—

TABLE *showing the total Mortality of both Sexes, and of all Ages, in certain Streets.*

STREET.	Character of Inhabitants.	Total Population, Census of 1871.	Deaths from all causes in 4 years, 1867-70.	Mortality per 1000 per annum, calculated on the Census of 1871—all ages.
Rodney	Respectable First and Second Class Houses, inhabited by well-to-do persons.	607	26	10·71
Egerton	Clerks, Custom-House Officers, and Skilled Artizans.	357	38	26·61
Henry Edward	Poor Population, Artizans, Dock Labourers, etc. etc.	677	81	29·91
Adlington	...	936	120	32·10
Bispham	...	716	92	32·12
Lace	...	715	102	35·70
Addison............	...	688	125	45·40
Sawney Pope ...	...	1016	227	55·86

The comparative mortality amongst children in the same streets tells a similar tale. Thus, out of 100 children under 1 year of age, it was found that "only 5 die annually in Rodney Street; 58 die in Lace Street; 40, in Sawney Pope Street; 30, in Adlington;

and from 21 to 26, in the other streets." Or again, taking the mortality among 100 children under 5 years of age and over 1, there die annually (in round numbers)—

In Rodney Street	4	Children.
,, Egerton Street	10½	,,
,, Henry Edward Street . . .	11½	,,
,, Addison Street	12½	,,
,, Adlington Street	13	,,
,, Bispham Street	14	,,
,, Lace Street	16	,,
,, Sawney Pope Street . . .	26	,,

The following statistics from Dr. Buchanan's Reports, when health officer of St. Giles, are interesting, inasmuch as they show that the same differences in the mortality-rate in different London streets are as marked as in Liverpool :—

TABLE *to show Mortality in some London Streets.*

PLACE.	1861. Annual mortality per 1000 of population, all ages.			1862. Annual mortality per 1000 of population.			1863. Annual mortality per 1000 of population.		
	Total.	Under 5 yrs.	Percentage of deaths under 5 years to total deaths.	Total.	Under 5 yrs.	Per cent.	Total.	Under 5 yrs.	Per cent.
Bedford Square............	12·9	3·3	26·6	17	6·1	37·9	16·2	6·1	37·6
Russell Square	14·2	3·9	27·4	13·5	4·0	29·6	12·9	2·7	16·0
Church Lane, St. Giles	30·6	16·5	54·0	34·2	16·6	48·6	30·1	13·4	44·6
Dudley Street, St. Giles	32·4	16·2	50·0	31·1	15·9	51·2	30·9	17·2	55·5
Short's Gardens, St. Giles	34·7	16·6	47·9	39·1	15·4	39·4	37·7	17·8	47·3

"On comparing this table with those of the Liverpool streets, it appears that there are streets in Liverpool as

healthy as these fine squares in London, and that there are streets in St. Giles in London which have a mortality equal to many of the Liverpool streets, though certainly even St. Giles does not approach the great mortality of Addison and Sawney Pope Streets.

"The mortality of children under 5 years in St. Giles assumes, however, relative proportions as great as in Liverpool, and doubtless owns the same causes. But what makes the great difference between the two cities is, that in Liverpool there is a large relative proportion of streets with high mortality, while in London the mean mortality of the whole city is reduced by the preponderance of healthy streets and districts.

"The effect of the excessive infant mortality ot Liverpool is to reduce the average age at death. That is, if the total years at death of all who die are divided by the number of deaths, the average age at death is in some wards only 14 years, and in one or two cases is reduced to 10 years, while in the borough at large it is 22 or 23 years."

But the mean mortality at all ages was also found to be excessive in the selected streets. Thus, to quote one or two instances,—"At 35 years of age, when life is most vigorous, 1000 persons of that age in the healthy districts of England lose only 10 lives in a year, Bispham Street loses 20, Adlington Street 34, and Sawney Pope Street 44. At 45 years of age, in the healthy districts of England, only 12 die out of 1000 persons, 57 die in Sawney Pope Street, and 62 in Addison Street; while the lowest mortality—viz. 29 in Henry Edward Street—is still nearly $2\frac{1}{2}$ as much as in the healthy districts."

What, then, are the causes of this excessive mor-

tality, which prevails in Liverpool even in non-epidemic years? Chiefly these:—surface-crowding, indoor overcrowding, want, exposure, immorality, and intemperance. Phthisis and bronchitis were found to be the principal fatal diseases amongst persons over five years of age; and convulsions, atrophy, and lung affections, amongst the children. As the same causes of disease are in operation in all our large towns, and are becoming yearly more wide-spread and general in proportion to the steady increase of urban populations, the following remarks by Professor Fawcett are of deep import and significance:—"It will, therefore, be well distinctly to appreciate what is implied in bringing into operation causes which will produce greater mortality; some definite idea may be formed on the subject, by considering the results involved in the present high death-rate prevailing amongst the children of the poor. Assume that there are 1000 of these children, that 500 of them die before the age of five, whereas, if they were as well cared for as the children of more wealthy parents, only 200 of them would die before this age. The death, therefore, of 300 is to be traced to defects in our social and economic condition. These children are literally slaughtered, and in a manner, moreover, which indicates prolonged suffering. But this is only a part, and perhaps the smaller part, of the mischief that is done; the causes which produce this excessive mortality do not alone affect the children who die; all those who survive are also brought under the same blighting influence. Consequently, to all the struggle for existence becomes more severe; the more weakly succumb; even the stronger who survive, in passing through the trying ordeal often contract the germs of future disease,

their constitutions being, in too many cases, undermined. Physical deterioration ensues, and a whole people may thus become gradually stunted and enfeebled." (*Pauperism; its Causes and Remedies.*)

These data, fragmentary though they be, will suffice to show not only the necessity of constant and systematic attention on the part of the health officer to the vital statistics of his district, but also the immense assistance which a logical use of them will afford him in estimating rightly the separate or combined influences of avoidable or removable causes of disease.

Section IV.—Duties required of the Health Officer for the efficient Execution of the Sanitary Acts.

As the health officer must "be prepared to advise the sanitary authority on all sanitary points involved in the action of the sanitary authority or authorities," it is necessary that he should be acquainted with the various Acts, or portions of them, which more immediately concern his office. A summary of these is given in Appendix I., as well as a synopsis of the subjects for the regulation of which sanitary authorities are empowered to make bye-laws. By referring to this summary, or to Glen's *Public Health and Local Government Laws*, from which it has been chiefly compiled, it will at once be seen that ample powers are possessed by sanitary authorities throughout the country to deal with material causes of disease, and enforce their removal. And here it may be observed, that though the Public Health Act, 1872, permits the health officer to "exercise any of the powers with which an inspector

of nuisances is invested by the Sanitary Acts, or any of them," it is not his duty to search for nuisances;—"that is the duty of the sanitary inspector. Those medical officers who are for ever prying about, searching for nuisances, by no means maintain the dignity of their office. They lose caste by being esteemed mere superior inspectors of nuisances. Let the medical officer of health by all means make an inspection whenever necessary; but it can rarely be requisite that he should make a primary inspection of a nuisance. He should first receive a report from the inspector of nuisances, and then view the nuisance himself, or act as he (the health-officer) thinks fit. There is still a greater objection to the medical officer of health instituting legal proceedings. This should never be done except by the order of the Sanitary Committee, and the inspector of nuisances is the informing officer who takes out the summons and acts the part of public prosecutor. The medical officer of health is the medical adviser of the sanitary authority, and when he appears in a police court, it is as a medical expert deposing as to the influences on health to the existence of which the sanitary inspector testifies." (See the valuable articles on *The Duties of Medical Officers of Health,* in "Med. Times and Gazette" for November 1872.)

In all cases the sanitary inspector should act under the supervision and by the direction of the medical officer of health. It will be his duty to inquire into the existence of nuisances, of whatever description; to inspect lodging-houses and houses suspected of over-crowding; to visit houses where there are cases of fever, and if necessary to attend to the removal of the patients to hospital; to inspect slaughter-houses, market-places,

and places where noxious trades are carried on; and, in short, to be the ever-ready assistant of the health officer in informing him concerning the existence of all removable causes of disease within his district.

1. *Overcrowding.*—One of the gravest responsibilities attaching to the office of health officer, and one, moreover, in every way most difficult to discharge satisfactorily, rests on the course of action which he must follow with regard to the wide-spread evil of overcrowding, and to habitations which he may consider unfit for occupation. Both are nuisances removable by law, but only on the certificate or evidence of the health officer, or by virtue of any bye-laws which may be in force in the district. In previous parts of this work the necessity for an ample amount of cubic space for the requirements of perfect health has been strongly insisted on—an amount, however, which it is impossible to obtain or enforce in the dwellings of the poorer classes and in lodging-houses. Practically it is found that 300 cubic feet per head is the highest *minimum* which can be enforced in most large towns, but it is desirable that this *minimum* should be increased wherever circumstances reasonably admit of such increment. In the strict letter of the law (see Appendix I.) no distinction is drawn whether overcrowders are of one family or more; the only distinction which is often made applying to children, who, in many bye-laws, are supposed to require less cubic space than adults. With regard to this point, Mr. Simon observes—"It is to be desired that laws and regulations as to overcrowding should not proceed on the assumption that children (to any measurable extent) require less breathing-space than adults. Against any such assumption two facts have to be considered

—first, that even healthy children, in proportion to their respective bodily weights, are about twice as powerful as adults in deteriorating the air which they breathe; secondly, that the children will almost invariably have certain eruptive and other febrile disorders to pass through, from which adult life is comparatively exempt, and in which the requirement of space is greatly increased. And having regard to these two considerations, I think it best that children and adults should be deemed to require equal allowances of air and ventilation." (See *Eighth Report of the Medical Officer of the Privy Council.*)

2. *Lodging-houses.*—As an example of the regulations which should be enforced with regard to lodging-houses, in pursuance of the Sanitary Act 1866, the following, which were adopted by the Board of Works for the Poplar district, may be quoted, and may serve as a guide for the sanitary authorities of other districts in framing regulations under the Act:—

"1. Whenever the board shall deem it necessary to put these regulations in operation in respect to any house let in lodgings, or occupied by members of more than one family, they shall give notice to the owner thereof of their intention to do so, specifying the day from which these regulations shall be deemed to be in force, such notice to be signed by the clerk of the board, and left on, or affixed to, the premises, the subject of such notice.

"2. A register shall be kept at the offices of the board of all houses to which these regulations shall from time to time be made to apply, and such register shall specify the following points:—

"The name and address of the owner of the house.

"The name of the person letting the rooms to, or receiving the rents of rooms from, the tenants of the rooms.

"The cubical measurement of each room.

"The number of persons allowed to sleep in each room, when occupied only as a sleeping room, or when occupied both as a sleeping and a day room.

"The rooms in the house allowed to be occupied as sleeping rooms.

"3. The person paying or liable to pay parochial rates for such house, or having paid them at the last collection, or who shall receive the rents either on his account or as agent to the owner, or as clerk or servant of such agent, shall be deemed to be the owner for the purposes of these regulations ; and so long as his name stands on the register as owner or receiver of rents, such register to be at all times received as proof of such ownership or receiving the rents.

"4. The notice of the intention to place any house upon the register shall be accompanied by two copies of the regulations in force in the district at the time, and by tickets in duplicate specifying the address of the house, the name and address of the owner, rooms permitted to be used as sleeping rooms, and the number of persons allowed to sleep in each room, according as it is used for a day room and a sleeping room, or as a sleeping room only ; which ticket, with one copy of the regulations, he shall keep affixed in some conspicuous place in the interior of the house, renewing the same when torn down or defaced, and he shall produce one of such duplicate tickets whenever required to do so by the board, or any officer thereof appointed to inspect such houses, and no greater number of persons shall be accommodated in any room than shall be specified upon such ticket. Each ticket shall be signed by the medical officer of health, and countersigned by the clerk to the board.

"5. No room, the ceiling of which is on a level with or below the level of the footpath or roadway immediately adjoining, and no room used as a kitchen or scullery, and no room not lighted and ventilated directly from the exterior, and no room in the roof of the house not furnished with an open fireplace or flue, shall be permitted to be occupied as a sleeping room, nor shall any underground room be permitted to be so occupied, unless it be specially certified by the medical officer of health as in his opinion fit to be so occupied without danger to the health of the occupants.

"6. In case of other rooms, the number of persons who may occupy a room for sleeping in, shall be determined by the cubical contents of the room, in manner as follows :—If the room be used only as a sleeping room, there shall not be more than one person to every three hundred cubical feet of air contained in such room.

If the room be used both as a sleeping room and a day room, then there shall be not more than one person to every four hundred cubical feet of air contained in such room.

"7. Persons of different sexes shall not occupy the same sleeping room, except one married couple, or parents with their children apparently under ten years of age, or any children under that age.

"8. The owner of every registered house shall cause every room and all the passages of such house to be ventilated to the satisfaction of the medical officer of health, and the board shall have power to cause the windows, window-sashes, and chimney-flues, to be constructed or reconstructed and altered for this purpose as they shall think fit, and may serve a notice upon the owner to make such alterations; and, in the event of the notice not being complied with, may make such alterations themselves, charging the expense upon the owner, and recovering the same in the same manner as penalties imposed under these regulations.

"9. The owner of every registered house shall provide a fit place and efficient accommodation for washing to any tenant or occupier in the house, at such times and under such regulations as he may deem fit for the preservation of good order.

"10. A water-closet, with a sufficient supply of water so laid on as effectually to flush the same, shall be provided for every such house having a yard or other facilities for the erection thereof, and where such facilities do not exist, or where the closet is used in common by the lodgers of two or more houses, a closet similarly supplied with water must be provided in some other place contiguous, to the satisfaction of the medical officer of health, and a separate closet shall be provided for such a number of lodgers or occupiers as the board shall from time to time direct. The water-closet seat, floor, walls, ceiling, and door, shall be kept free from filth, and clean in every other respect, and there shall be a door to every such closet or privy.

"11. Every such house shall have an ample supply of water laid on to it, in such a manner and in such a quantity as shall be satisfactory to the medical officer of health. The cistern or butt shall be properly covered, and otherwise placed and arranged so as to preserve the water from contamination by dust or deleterious effluvia, and cleansed thoroughly once in every month.

"12. The yards and areas shall have proper surface-drainage,

and, if required, the owner shall, within a specified time, flag or pave them, or any part thereof, with such materials and in such manner as the medical officer of health shall direct, and shall repave or repair them as he may be required from time to time. Every house shall also be provided with a proper covered dust-bin, of sufficient size to contain the dust, ashes, and ordinary house refuse, that accumulate in the intervals of its being carried away, which shall not exceed one week. In case of a public dust-bin having been provided for several houses in common, the board shall have power to increase the number of dust-bins, at the expense of the owners of the houses, as they may deem necessary. All the drains, closets, and sinks, shall be effectually trapped, so as to prevent effluvia coming up from the drains.

"13. The owner of every registered house shall cause the walls and ceilings of every room, and of the staircase and passages, and the yards of such house, to be well and sufficiently lime-whited, and the painted work washed with soap and water, and the house otherwise thoroughly cleansed, once in each year, or at any other time if required by the medical officer of health, and the roof of the house to be kept water-tight, and the flooring boards, walls, and ceilings, to be kept in a proper state of repair, and free from vermin, and shall cause the floors of all rooms, passages, and stairs of such house, together with the yards attached thereto, to be kept at all times clean swept, and washed as often as necessary. No dogs, swine, rabbits, pigeons, or other animals or birds, or meat, fruit, or vegetables, shall be kept in the sleeping apartments of any such house, or in the yard thereof, which shall be deemed to be likely to cause a nuisance, in the opinion of the medical officer of health.

"14. The medical officer of health, or servant of the board acting under his directions, shall be admitted upon the premises without delay at any hour between the hours of nine o'clock in the morning and ten at night, and on giving twelve hours' notice on the premises of his intention to visit at night at any hour between ten at night and nine o'clock in the morning, and shall be admitted to all the rooms, or to any room, without delay, in order to see whether the regulations in force are being complied with.

"15. The landlord or occupier of every registered house shall, when a person in such house is ill of smallpox, fever, or any other dangerous infectious disease, give immediate notice in writing

to the medical officer of health at the offices of the board, and shall carry out without delay, in respect thereof, any measures for disinfection that he may direct.

"16. The owner or occupier of any registered house shall attend any meeting of the board, or sanitary committee thereof, to which he shall be summoned by letter or notice left at least three days clear beforehand at the house referred to, to answer any complaint made against him, or either of them, in respect to neglect of these regulations, and shall forthwith carry out such order as he may receive from the board, or sanitary committee, or medical officer of health, made with a view to bring his house into conformity therewith.

"17. A copy of these regulations shall be left for the owner of the premises affected, by the officer appointed by the board, as soon as his house is registered, and the infringement of any regulation shall render the offender liable to penalities not exceeding 40s. for any one offence, with an additional penalty not exceeding 20s. for every day during which a default in obeying such regulations may continue.

"The penalties shall be recovered in the same manner as directed by the 54th Section of the Sanitary Act 1866."

For further provisions concerning lodging-houses, see Appendix I.

3. *Dwellings unfit for Habitation.*—With regard to dwellings which are so dilapidated as to be unfit for occupation in districts where the Artizans' and Labourers' Dwellings' Act is in force, it will be the duty of the health officer to report to the local sanitary authority on all such buildings, leaving it to the engineer or surveyor to point out what improvements may be necessary, or whether the whole of the premises, or parts of them, should be demolished. According to the Statute (see Appendix I.), such report may be of the briefest description, and unless encouraged by the sanitary authority to make suggestions, the health officer should merely certify that such and such buildings, in their present state

or condition, are dangerous to health, and unfit for human habitation. With regard to such buildings, Mr. Simon observes,—"By places 'unfit for human habitation,' I mean places in which, by common consent, even moderately healthy life is impossible to human dwellers—places which therefore in themselves (independently of removable filth which may be about them) answer to the common conception of 'nuisances;' such, for instance, as those underground and other dwellings which are in such constructional partnership with public privies, or other depositories of filth, that their very sources of ventilation are essentially offensive and injurious; and dwellings which have such relations to local drainage that they are habitually soaked into by water or sewage, and so forth. But beyond these instances where the dwelling would, I think, even now be deemed by common consent 'unfit for human habitation,' instances varying in degree are innumerable, where, in small closed courts, surrounded by high buildings and approached by narrow and perhaps winding gangways, houses of the meanest sort stand, acre after acre of them, back to back, shut from all enjoyment of light and air, with but privies and dust-bins to look upon; and surely such can only be counted 'fit for human habitation' while the standard of that humanity is low. Again, by 'overcrowded' dwellings, I mean those where dwellers are in such proportion to dwelling-space that no obtainable quantity of ventilation will keep the air of the dwelling-space free from hurtfully large accumulations of animal effluvium—cases where the dwelling-space at its best stinks more or less with decomposing human excretions, and where at its worst this filthy atmosphere may (and very often does) have working and spreading

within it the taint of some contagious fever. And as a particular class of cases, in which both evils are combined in one monstrous form of nuisance, I ought expressly to mention certain of the so-called 'tenement-houses' of the poor; especially those large but ill-circumstanced houses, once perhaps wealthily inhabited, but now pauperised, and often without a span of courtyard either front or back; where in each house, perhaps, a dozen or more rooms are separately let to a dozen or more families—each family with but a room to itself, and perhaps lodgers; and where in each house the entire large number of occupants (which even in England may be little short of a hundred) will necessarily have the use of but a single staircase, and of a privy, which perhaps is placed in the cellar." (See *Eighth Report of the Medical Officer of the Privy Council.*)

This was written in 1865, and since then the Sanitary Act of 1866, and the Artizans' and Labourers' Dwellings' Act of 1868, have been passed to remedy the evils so forcibly described by Mr. Simon. In reporting upon such dwellings, the medical officer of health must always take into account the general circumstances relating to the house-accommodation of his district, bearing in mind that sanitary improvements, even though they can be enforced by law, must be gradual where the evils to deal with are so gigantic, and that the house-accommodation, bad though it be, is better than no accommodation at all. (See Chapter VIII.)

With regard to cleanliness of premises, however, such as whitewashing, removal of filth, etc., he should have no hesitation in urging the sanitary authority to put in force the powers with which they are invested

by the Statutes, and see that they are carried out. (See Appendix I.)

4. *Cellar-dwellings.* (See Appendix I.)

5. *Food.*—The duties of the health officer in respect to the inspection of food, and directions for its examination, are given in Appendix I. and Chapter II. Health officers, who are also public analysts under the Adulteration Act of 1872, must be specially qualified.

6. *Infectious or Contagious Diseases.*—This subject has been already so fully treated in the previous chapter, that little more need be said here. The statutory powers are given in Appendix I., together with the orders of the Local Government Board, relating more especially to smallpox epidemics and quarantine.

In the presence of any epidemic prevailing in or threatening his district, it will devolve on the health officer to recommend or not, as he thinks fit, the enforcement of the Prevention of Diseases Act, and it need hardly be said that this discretionary power should be exercised with all due discrimination, because the Sanitary Act of 1866 gives the sanitary authority full power to deal with all such diseases occurring within the district. Under the provisions of this Act, the health officer may recommend the erection of a contagious diseases hospital (see Chaper IX.), a mortuary or mortuaries, disinfecting premises, etc. With these aids for the prevention of epidemic disease, and the powers conferred by the Act with respect to the removal of the sick, disinfection, etc., it can only, in cases of the gravest emergency, and when the health of the district is seriously endangered, be incumbent on the health officer to recommend the enforcement of the Diseases Prevention Act.

As regards this subject, the following remarks from the articles in the *Medical Times and Gazette,* already referred to, are well worth quoting :—" On the promptitude, energy, tact, and skill, of the medical officer, it will in a great measure depend whether a disease spreads or not. At the same time we must warn him against becoming an alarmist. If a medical officer once cries 'Wolf!' and no wolf comes, his advice is liable to be thought of little account when he again raises the alarm of an impending epidemic. The prognosis of an epidemic must be given with great caution and reserve.

" As regards the detailed measures to be taken to check infectious and contagious diseases, our own practice, which works well, is to instruct the sanitary inspector to visit and keep under surveillance every house in which enteric fever, typhus, relapsing fever, scarlet fever, diphtheria, smallpox, or diarrhœa has appeared, and to report to us on the sanitary or unsanitary condition of the premises. No difficulty is experienced in gaining access to even the best class of houses, if the sanitary inspector exercises tact and discretion. Let it be known that the object is to advise the inmates as to the best course to pursue, and that no officiousness or interference with the treatment of the patient is intended. In cases of difficulty, or where several cases of the disease have existed in a house or neighbourhood, it will be requisite that the medical officer should himself visit. Care should be taken to insure as far as possible the use of disinfectants. And where the sanitary authority sanctions the practice, it is a wise economy to furnish disinfectants gratuitously to those who are very poor, but this should not be done without the authority of the board under whom the

medical officer of health acts. All defects of construction in the infected house must be remedied as far as possible, and all unsanitary influences at once removed where practicable. As soon as the patients are convalescent or removed to hospital, or at the earliest practicable moment after a death, due care must be exercised by the inspector acting under the direction of the health officer to have the infected house disinfected and cleansed."

With regard to cases of diarrhœa such minute supervision would not apply unless the disease appeared in an endemic form, when special attention should be directed to the water-supply and the drainage. All this, however, has been fully dealt with in previous chapters, and need not be further commented on.

7. *Routine of Duty.*—This, of course, will very much depend on the nature and extent of the district, but in all cases it is necessary that the duties should be crrried on systematically. As already stated, the sanitary inspector or inspectors should be under the entire supervision of the medical officer, and any orders from the sanitary authority affecting the duties of these officials should always be conveyed through him, otherwise he cannot be held responsible for the efficient working of his department.

In the articles in the *Medical Times and Gazette* already referred to, the following sketch of the daily routine in a large metropolitan parish is given as a guide for commencing health officers:—"At 9 A.M. the subordinate officers arrive at the office. They consist of a clerk, a messenger (who is always a copying clerk), the sanitary inspectors, to each of whom a district is assigned, and a disinfector. Shortly after the medical

officer arrives, reads his letters, confers with the clerk, gives directions as to the correspondence of the day, receives verbal reports from the inspectors as to the previous day's work, and makes appointments for these officers to meet him at particular places during the course of the day, should his presence be deemed necessary in particular cases. In a few minutes a large amount of routine work can thus be got through, whilst reports for committees, special correspondence, and the examination of the books of the department, can be despatched, say twice or thrice a week, at any convenient time. Between 9 and 10 A.M. each inspector writes out a brief diary of his previous day's work for the information of the medical officer, and instructs the disinfector as to houses where disinfection is required. At 10 the sanitary inspectors depart on their daily rounds, having previously informed themselves as to any new complaints requiring their attention. After their departure the clerk extracts and summarises their diaries, and enters the results in the proper books. The books actually in use are—(1.) The medical officer's diary, in which he briefly enters the dates of visits made, with any particulars he thinks fit. (2.) A book for receiving the complaints of ratepayers and others. (3.) A record of houses in which infectious disease has appeared. (4.) The diaries of the several sanitary inspectors. (5.) A book recording the progress of works, which exhibits at a glance the visits made and the works executed at any particular house. From this the clerk extracts, and presents weekly to the medical officer—(6.) A list of works in arrear. (7.) A report book in which the health officer reports to the sanitary committee all ordinary cases of nuisances uncompleted, together with

his recommendations. Further, the sanitary inspectors are provided with forms of notice of nuisances, arranged in books with duplicates, after the manner of a cheque-book. These arrangements may seem complicated. In practice, however, they are found to be simple and effective. Where little or no clerical assistance is furnished, they may be much simplified, and the books reduced in number."

In small rural districts, when special clerical assistance is not required, the sanitary inspector should keep some of the books if necessary.

8. *Reports.*—All reports from the health officer to the sanitary authority should be concise and to the point, and studiously considered, because they may be called for in a court of law. The stated reports, weekly, quarterly, or otherwise, will deal chiefly with the vital statistics of the district, and enumerate such proceedings as have been undertaken according to the provisions of the Sanitary Acts, together with any suggestions which he may deem it to be his duty to lay before the sanitary authority from time to time. He should avoid entering into lengthy disquisitions, because he will have the opportunity, at meetings of the sanitary authority, of answering any questions, and justifying his recommendations, should he be called upon to do so. As far as possible, he should base his stated reports on a uniform plan, and he may be quite sure that the briefer they are in their completeness, the more they will be appreciated. Annual reports should embrace all the points indicated in the regulations of the Local Government Board, previously quoted.

9. *Official Conduct.*—With regard to his subordinates, the medical officer should endeavour to arouse in them

an *esprit de corps,* not doing their work, but seeing that they do it themselves efficiently and readily. He should listen courteously to any remarks or suggestions which they may make, and if they are trained officers, give them credit for knowing their duties as well as he does his own. In their own sphere they are as sensitive to rebuke as himself, and it should, therefore, never be administered unless it is merited. Any serious delinquency or inefficiency on their part should be laid before the sanitary authority, and those who do perform their duties satisfactorily should be as frankly commended. Above all, punctuality should be insisted on. In cases where the health officer will have to educate sanitary inspectors who are new to the work, it would be desirable that all candidates for such an important post should pass a certain period of probation before their appointment is confirmed by the sanitary authority.

As regards the portion of the community committed to his charge, he should endeavour conscientiously, and to the best of his ability, to fulfil his obligations towards them, and if in practice, he should in no wise shirk his public duty, even at the risk of losing his best patient. In this, as in all other affairs of life and conduct, it will be found that in the long run "honesty is the best policy."

Towards his medical brethren he should religiously observe the ethics of his profession, and act up to the golden rule,—"Do to others as you would be done by." He should endeavour to be on friendly terms with all within his district, and never hesitate to court their assistance and advice when he feels that he may require them in the discharge of his duties. It need hardly be

said that all such favours or obligations should be readily and ungrudgingly reciprocated on his part.

His relations to the sanitary authority should be guided by common sense and a sense of duty. He should always remember that he is their medical adviser, not their dictator; and at their meetings he should carefully avoid taking part in discussions on his reports, unless called upon to do so, or in reply to objections. He should attend no meetings except those at which his presence is requested or expected; and when he has to attend, he should support his views, when called upon, with clearness, firmness, courtesy, and tact. His proposals may be rejected, but if they do not lie within the scope of the statutory enactments requiring their enforcement, he should never resent opposition, but again bring them forward on future occasions. But with regard to breaches of sanitary law, which in spite of his representations may be persistently ignored, he should unhesitatingly insist upon their being remedied, and, failing action, he can always appeal to the Local Government Board. It is to be hoped, however, that he will seldom meet with such unwarrantable opposition. Under all circumstances he should strive to exercise a wise forbearance when he can conscientiously do so, and on all occasions maintain a courteous, dignified, and friendly demeanour towards the sanitary authority, feeling assured that tact and good temper, like good words, " are worth much, and cost but little."

APPENDIX.

I.

Subject to the provisions of the Public Health Act 1872, the Local Government Acts shall be deemed to be in force within the district of every urban sanitary authority, and from and after the first meeting of an urban sanitary authority, in pursuance of this Act, there shall be transferred and attach to an urban sanitary authority, to the exclusion of any other authority which may have previously exercised or been subject to the same,—all powers, rights, duties, capacities, liabilities, and obligations within such district exercisable or attaching by and to a local board under the Local Government Acts, and by and to the sewer authority under the Sewage Utilisation Acts, and by and to the nuisance authority under the Nuisances Removal Acts, and by and to the local authority under the Common Lodging-Houses' Acts, the Artizans' and Labourers' Dwellings Act, and the Bakehouse Regulation Act, or by and to any of the said authorities under any of such Acts, or any Acts amending such Acts.

Where the Baths' and Washhouses' Acts, and the Labouring-Classes' Lodging-Houses' Acts, or any of them, are in force within the district of any urban sanitary authority, such authority shall have all powers, rights, duties, capacities, etc., in relation to such Acts exercisable by or attached to the council, incorporated commissioners, local board, improvement commissioners, and other commissioners or persons acting in the execution of the said Acts, or any of them.

Where the Baths' and Washhouses' Acts are not in force within the district of any urban sanitary authority, such urban sanitary authority may adopt such Acts ; and where the Labouring Classes' Lodging-Houses' Acts are not in force within the district of any urban sanitary authority, such urban sanitary authority may adopt such Acts. (*Sect.* 7.)

Subject to the provisions of this Act, and from and after the first meeting of a rural sanitary authority, in pursuance of this Act, there shall be transferred and attach to a rural sanitary authority, to the exclusion of any other authority which may have previously exercised or been subject to the same, all powers, rights, duties, etc., within such district, exercisable or attaching by and to the sewer authority under the Sewage Utilisation Acts, and by and to the nuisance authority under the Nuisances Removal Acts, and by and to the local authority under the Common Lodging-Houses' Acts, the Disease Prevention Act, and the Bakehouse Regulation Act, or by and to any of the said authorities under any such Acts, or any Acts amending such Acts. (*Sect.* 8.)

While the above sections of the Public Health Act 1872 show what Acts are in force in urban and rural districts, the following excerpts from Glen's *Public Health and Local Government Laws* represent the portions of them which more immediately concern the duties of the health officer, and the sanitary inspectors working under him :—

1. *Removal of Nuisances, etc.*—The Nuisances Removal Acts, and the amending Acts, are in force throughout England and Wales, in both urban and rural districts. The Acts define the word "nuisances" as including—

(1.) Any premises in such a state as to be a nuisance, or injurious to health.

(2.) Any pool, ditch, gutter, watercourse, privy, urinal, cesspool, drain, or ashpit, so foul as to be a nuisance, or injurious to health.

(3.) Any animal so kept as to be a nuisance, or injurious to health.

(4.) Any accumulation or deposit which is a nuisance, or injurious to health.

But it expressly provides that no such accumulation or deposit as shall be necessary for the effectual carrying on of any business or manufacture shall be punishable as a nuisance, when it is proved to the satisfaction of the justices that the accumulation or deposit has not been kept longer than is necessary for the purpose of such business or manufacture, and that the best available means have been taken for protecting the public from injury to health thereby. (*Nuisances Removal Act* 1855, sect. 8.)

By the Sanitary Act, 1866, the word "nuisances," under the Nuisance Removal Act, shall include—

(1.) Any house or part of a house so overcrowded as to be dangerous to the health of the inmates.

(2.) Any factory, workshop, or work-place, not already under the operation of any general Act for the regulation of factories or bakehouses, not kept in a cleanly state, or not ventilated in such a manner as to render harmless, as far as practicable, any gases, vapours, dust, or other impurities generated in the course of the work carried on therein, that are a nuisance, or injurious, or dangerous to health, or so overcrowded while work is carried on as to be dangerous or prejudicial to the health of those employed therein.

(3.) Any fireplace or furnace which does not, as far as practicable, consume the smoke arising from the combustible used in such fireplace or furnace, and is used within the district of a nuisance (sanitary) authority, for working engines by steam, or in any mill, factory, dye-house, brewery, bakehouse, or gas-work, or in any manufactory or trade process whatsoever.

(4.) Any chimney (not being the chimney of a private dwelling-house) sending forth black smoke in such quantity as to be a nuisance. (*Sect.* 19.)

By the Nuisances Removal Act, and other Acts amending the same, it is further enacted with regard to—

(1.) *Noxious Trades and Manufactures.*—If any candle-house, melting-house, melting-place, or soap-house, or any slaughter-house, or any building or place for boiling offal or blood, or for boiling, burning, or crushing bones, or any manufactory, building, or place used for any trade, business, process, or manufacture, causing effluvia (situate within the limits of any city, town, or populous district), be at any time certified to the local (sanitary) authority by any medical officer (of health) to be a nuisance, or injurious to the health of the inhabitants of the neighbourhood, the sanitary authority shall direct complaint thereof to be made before any justice. (*Nuisances Removal Act* 1855, sect. 27.)

(2.) *Overcrowded Dwelling-houses.*— Whenever the medical officer of health certifies to the local (sanitary) authority that any house containing more than one family is so overcrowded as to be dangerous or prejudicial to the health of the inhabitants, the sanitary authority is to cause proceedings to be taken before the justices to abate such overcrowding. The house need not be what is commonly understood by the term of a "common lodging-house;" for the Act applies to any house, the inhabitants whereof

shall consist of more than one family, and by the Sanitary Act 1866 it also includes, as already stated, "any house or part of a house so overcrowded as to be dangerous or prejudicial to the health of the inmates." (*Nuisances Removal Act* 1855, sect. 29.)

(3.) *Cellar Dwellings.*—By the Sanitary Act 1866, the 67th section of the Public Health Act 1848, relating to cellar dwellings, shall apply to every place in England and Wales where such dwellings are not regulated by any other Act of Parliament. No vault, cellar, or underground room, built or rebuilt after the passing of the Public Health Act 1848, or which shall not have been so let or occupied before the passing of that Act, is to be let or occupied separately as a dwelling; and no vault, cellar, or underground room whatsoever, can be let or occupied separately as a dwelling unless there be outside of and adjoining, and extending along the entire frontage, and upwards of from six inches below the level of the floor up to the surface of the street or ground, an open area of at least two feet six inches wide in every part; nor unless it be well and effectually drained by means of a drain, the uppermost part of which is one foot at least below the level of the floor; nor unless there be appurtenant the use of a water-closet or privy and an ashpit, furnished with proper doors and coverings kept and provided according to the provisions of the Act; nor unless it have a fireplace with a proper chimney or flue; nor unless it have an external window, of at least nine superficial feet in area clear of the sash-frame, and made to open in such manner as shall be approved by the surveyor, except in case of an inner or back vault, cellar, or room, let or occupied along with a front vault, cellar, or room, as part of the same letting or occupation, in which the external window may be of any dimensions, not being less than four superficial feet in area clear of the sash-frame.

Every vault, cellar, or underground room, in which any person passes the night, is to be deemed to be occupied as a dwelling within the meaning of the Act; and the law as regards overcrowding applies to these as to other dwellings.

(4.) *Disinfecting Premises.*—By the 22d section of the Sanitary Act 1866 it is enacted that if the nuisance (sanitary) authority shall be of opinion, upon the certificate of the health officer, that the cleansing and disinfecting of any house, or part thereof, and of any articles therein calculated to retain infection, would tend to prevent or check infectious or contagious diseases,

it shall be the duty of the sanitary authority to give notice in writing requiring the owner or occupier of such house, or part thereof, to cleanse and disinfect the same as the case may require. If the person to whom notice is so given fail to comply therewith within the time specified, he shall be liable to a penalty of not less than one shilling and not exceeding ten shillings for every day during which he continues to make default; and the sanitary authority shall cause such house, or part thereof, to be cleansed and disinfected, and may recover the expenses incurred from the owner or occupier in a summary manner. When the owner or occupier is, from poverty or otherwise, unable, in the opinion of the sanitary authority, effectually to carry out the requirements of the section, such authority may, without enforcing such requirements on such owner or occupier, with his consent, at its own expense, cleanse and disinfect such house, or part thereof, and any articles therein likely to retain infection.

(5.) *Disinfecting-Chamber.*—The nuisance or sanitary authority in each district may provide a proper place, with all necessary apparatus and attendance, for the disinfection of woollen articles, clothing, or bedding, which have become infected, and they may cause any articles brought for disinfection to be disinfected free of charge. (*Sanitary Act* 1866, sect. 23.)

(6.) *Carriages for Conveyance of Infected Persons.*—It is provided by the Sanitary Act 1866, that it shall be lawful at all times for the sanitary authority to provide and maintain a carriage or carriages suitable for the conveyance of persons suffering under any contagious or infectious disease, and to pay the expenses of conveying any person therein to a hospital or place for the reception of the sick, or to his own home. (*Sanitary Act*, sect. 24.)

(7.) *Hospitals.*—Any sewer (sanitary) authority or urban sanitary authority may provide, for the use of the inhabitants within its district, hospitals or temporary places for the reception of the sick. Such authority may itself build such hospitals, or places of reception, or make contracts for the use of any existing hospital or part of a hospital, or for the temporary use of any place for the reception of the sick. (*Sanitary Act*, sect. 37.)

(8.) *Removal of Sick to Hospitals.*—Where a hospital or place for the reception of the sick is provided within the district of a sanitary authority, any justice may, with the consent of the superintending body of such hospital or place, by order, on a certificate signed by a legally-qualified medical practitioner, direct

the removal to such hospital or place for the reception of the sick, at the cost of the sanitary authority, of any person suffering from any dangerous or infectious disorder, being without proper lodging or accommodation, or lodged in a room occupied by more than one family, or being on board any ship or vessel. (*Sanitary Act*, sect. 26.)

(9.) *Mortuary Houses.*—Any nuisance (sanitary) authority may provide a proper place for the reception of dead bodies, and where any such place has been provided, and any dead body of any one who has died of any infectious disease is retained in a room in which persons live and sleep, or any body which is in such a state as to endanger the health of the inmates of the same house or room, any justice may, on a certificate signed by a legally-qualified medical practitioner, order the body to be removed to such proper place of reception at the cost of the sanitary authority, and direct the same to be buried within a time to be limited in such order. (*Sanitary Act*, sect. 27.)

Any nuisance (sanitary) authority may provide a proper place (otherwise than at a workhouse or at a mortuary house) for the reception of dead bodies for and during the time required to conduct any *post-mortem* examination ordered by the coroner of the district or other constituted authority, and may make such regulations as they may deem fit for the maintenance, support, and management of such place. (*Sanitary Act*, sect. 28.)

(10.) *Public Exposure of Persons labouring under Infectious Diseases.*—By the Sanitary Act 1866, sect. 38, any person suffering from any dangerous infectious disorder who wilfully exposes himself, without proper precaution against spreading the disorder, in any street, public place, or public conveyance, and any person in charge of one so suffering who so exposes the sufferer, and any owner or driver of a public conveyance who does not immediately provide for the disinfection of his conveyance after it has, with the knowledge of such owner or driver, conveyed any such sufferer, and any person who, without previous disinfection, gives, lends, sells, transmits, or exposes, any bedding, clothing, rags, or other things which have been exposed to infection from such disorders, shall, on conviction of such offence before any justice, be liable to a penalty. No such proceedings, however, shall be taken against persons transmitting with proper precautions any such bedding, clothing, rags, or other things, for the purpose of having the same disinfected.

If any person knowingly lets any house, room, or part of a house, in which any person suffering from any dangerous infectious disorder has been, to any other person, without having such house, room, or part of a house, and all articles therein liable to retain infection, disinfected to the satisfaction of a qualified medical practitioner (health officer), as testified by a certificate given by him, such person shall be liable to a penalty. For the purposes of this provision the keeper of an inn shall be deemed to let part of a house to any person admitted as a guest into such inn. (*Sanitary Act*, sect. 39.)

(11.) *Exposing for sale Meat unfit for Food.*—The medical officer of health or inspector of nuisances may, at all reasonable times, inspect and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, or flour, exposed for sale or of preparation for sale, and intended for the food of man; and in case any such animal, carcase, meat, etc., appear to him to be diseased, or unsound, or unwholesome, or unfit for the food of man, it shall be lawful for such medical officer of health or inspector of nuisances to seize, take, and carry away the same, or direct the same to be seized, taken, and carried away, by any officer, servant, or assistant, in order to have the same dealt with by a justice. (*Amendment Act* 1863, sect. 2.)

(12.) *Ditches, Drains, etc.*—All surveyors and district surveyors may make, scour, cleanse, and keep open, all ditches, gutters, drains, or watercourses, in and through any lands or grounds adjoining or lying near to any highway, upon paying the owner or occupier of such lands or grounds, provided they are not waste or common, for the damages which he will thereby sustain. (*Nuisances Removal Act* 1855, sect. 21.)

(13.) *New Sewers.*—Whenever any ditch, gutter, drain, or watercourse used, or partly used, for the conveyance of any water, filth, sewage, or other matter, from any house, building, or premises, is a nuisance within the meaning of the Act, and cannot, in the opinion of the local (sanitary) authority, be rendered innocuous without the laying down of a sewer, or of some other structure, along the same or part thereof, or instead thereof, the local authority are required to lay down such sewer, or other structure, and to keep the same in good and serviceable repair. (*Nuisances Removal Act* 1855, sect. 22.)

(14.) *Wells, etc.*—All wells, fountains, and pumps, vested in the local (sanitary) authority under the Act, shall be kept in good repair

and condition, and free from pollution. The sanitary authority may also keep in good repair and condition, and free from pollution, other wells, fountains, and pumps, dedicated to or open to the use of the inhabitants of such place. (*Nuisances Removal Act* 1860, sect. 7.)

(15.) *Inspection of Premises.*—The sanitary authority, by themselves or their officers, have power of entry upon premises, when they have reasonable grounds to believe that a nuisance exists, between nine o'clock in the morning and six in the evening. For the inspection of any carcase, meat, poultry, fish, etc., the sanitary authority, or their officers, may from time to time enter the premises at all reasonable hours during which business is carried on in such premises. (*Nuisances Removal Act* 1855, sect. 11.)

(16.) *Order for Abatement of Nuisances.*—This may be quoted as a summary of the preceding provisions. By their order the justices may require the person on whom it is made—

To provide sufficient privy accommodation, means of drainage or ventilation, or to make safe and habitable ;

Or to pave, cleanse, whitewash, disinfect, or purify the premises which are a nuisance or injurious to health, or such part thereof as the justices may direct in their order ;

Or to drain, empty, cleanse, fill up, amend, or remove the injurious pool, ditch, gutter, watercourse, privy, urinal, cesspool, drain, or ashpit, which is a nuisance or injurious to health ;

Or to provide a substitute for that complained of ;

Or to carry away the accumulation or deposit which is a nuisance or injurious to health ;

Or to provide for the cleanly and wholesome keeping of the animal kept so as to be a nuisance or injurious to health ;

Or, if it be proved to the justices to be impossible so to provide, then to remove the animal, or any or all of these things (according to the nature of the nuisance) ;

Or to do such work or acts as are necessary to abate the nuisance complained of, in such manner and within such time as in such order shall be specified. (*Nuisances Removal Act* 1855, sect. 13.)

2. *Common Lodging-Houses' Act* 1851.—This Act is in force both in rural and urban districts. The law-officers of the Crown have interpreted the Act as extending to "that class of lodging-houses in which persons of the poorer class are received for short

periods, and, although strangers to one another, are allowed to inhabit one room."

The local (sanitary) authority shall—

(1.) Keep a register of common lodging-houses, which shall contain the name of the person applying for registration, and the situation of each house ;

(2.) Make bye-laws for fixing number of lodgers, for promoting cleanliness and ventilation therein, with respect to inspection, and the conditions and restrictions under which such inspection shall be made ;

(3.) Have access, by persons producing written authority, for the purpose of inspection, or introducing or using any disinfecting process.

With regard to houses let in lodgings, or occupied by members of more than one family, it is further provided by the Sanitary Act 1866, sect. 35, that, on application by the local sanitary authority, the Local Government Board may declare the following enactment to be in force in the district, and from and after the publication of such notice, the sanitary authority shall be empowered to make regulations for the following matters (see Chapter XIV.) :—

(1.) For fixing the number of persons who may occupy a house, or part of a house, which is let in lodgings, or occupied by members of more than one family ;

(2.) For the registration of houses thus let or occupied in lodgings ;

(3.) For the inspection of such houses, and the keeping the same in a cleanly and wholesome state ;

(4.) For enforcing therein the provisions of privy accommodation, and other appliances and means of cleanliness, in proportion to the number of lodgings and occupiers, and the cleansing and ventilation of the common passages and staircases ;

(5.) For the cleansing and lime-whiting, at stated times, of such premises.

The owners or occupiers of all such registered houses are bound by law to give immediate notice of any case of fever or dangerous infectious disease occurring on the premises.

3. *The Labouring Classes' Lodging-Houses' Act* 1851 may be adopted for any incorporated borough, and also for any place being the district of any local board of health, and also for any place being the district within the limits of any Act for the

paving, lighting, watching, draining, or otherwise improving, such place. The Act may also be adopted for parishes containing a population of not less than 10,000. Under this Act the sanitary authorities may make or hold lodging-houses, and take loans for that purpose, and make regulations for their being well kept. (See Chapter VIII.)

4. *The Artizans' and Labourers' Dwellings' Act* of 1868 applies to all places in the United Kingdom having above 10,000 inhabitants. If, in any place to which the Act applies, the officer of health finds that any premises therein are in a condition or state dangerous to health, so as to be unfit for human habitation, he shall report the same, in manner hereinafter provided, to the local authority. Every such report shall be made in writing, and delivered to the clerk of the local authority, and the local authority shall refer such report to a surveyor or engineer, who shall thereupon consider the report so furnished to him, and report to the local authority what is the cause of the evil so reported on, and the remedy thereof; and if such evil is occasioned by defects in any premises, whether the same can be remedied by structural alterations and improvements, or otherwise, or whether such premises, or any and what part thereof, ought to be demolished.

5. *The Baths' and Washhouses' Acts* of 1846-48 enabled the inhabitants of towns, through the town-councils, to supply themselves with the means of cleanliness, and a great number of places have availed themselves of the powers given. By the 43d section of the Sanitary Act 1866, local boards may adopt these Acts for districts in which they are not in force.

6. *The Bakehouse Regulation Act* 1863 provides that no person under the age of eighteen years shall be employed in any bakehouse between the hours of 9 P.M. and 5 A.M. The inside walls and ceiling or top of every bakehouse situate in any city, town, or place containing, according to the last census, a population above 5000, and the passages and staircases leading thereto, shall either be painted with oil or lime-washed, or be partly painted and partly lime-washed; where painted, the painting shall be renewed once in seven years, and shall be washed with hot water and soap once at least in every six months; where lime-washed, the lime-washing shall be renewed once at least in every six months.

Every bakehouse, wherever situate, shall be kept in a cleanly

state, and shall be provided with proper means for effectual ventilation, and be free from effluvia arising from any drain, privy, or other nuisance.

No place on the same level with a bakehouse situate in any city, town, or place, containing more than 5000 persons according to the last census, and forming part of the same building, shall be used as a sleeping-place, unless it be constructed as follows—that is to say—

Unless it is effectually separated from the bakehouse by a partition extending from the floor to the ceiling.

Unless there be an external glazed window of at least nine superficial feet in area, of which at the least four and a half superficial feet are made to open for ventilation.

Any officer of health, inspector of nuisances, or other officer appointed by the local authority, may enter into any bakehouse at all times during the hours of baking, and may inspect the same, and examine whether it is or not in conformity with the provisions of the Act.

7. *Public Health Act* 1848, and *Local Government Acts.*—The powers and provisions under these various Acts, which more immediately concern the duties of health officers in urban or populous rural districts, may be stated under the following subdivisions :—

(1.) *Sewerage.*—Every such district must be efficiently drained and sewered, and to this end local sanitary authorities are vested with powers, either within or without their district, for the purpose of outfall and distribution of sewage, or for the sale of sewage and its distribution over any land, or for storing or disinfecting it, provided always that no nuisance is created thereby. (*Local Government Act* 1858, sect. 30.)

(2.) *Ditches, Drains, etc.*—The local sanitary authority are bound to drain, cleanse, cover, or fill up, or cause to be drained, cleansed, covered, or filled up, all ponds, pools, open ditches, sewers, drains, and places containing or used for the collection of any drainage, filth, water, matter, or thing of an offensive nature, or likely to be prejudicial to health. (*Public Health Act* 1848, sect. 58.)

(3.) *Cleansing Streets, removing Filth, etc.*—The local sanitary authority may, in their discretion, provide, in proper and convenient situations, boxes or other conveniences for the temporary deposit and collection of dust, ashes, and rubbish, and also fit,

buildings and places for the deposit of the sewage, soil, dung, filth, ashes, dust, etc., collected by such authority. (*Public Health Act* 1848, sect. 56.)

The local sanitary authority may themselves undertake or contract with any person for—

The proper cleansing and watering of streets ;

The removal of house-refuse from premises ;

The cleansing of privies, ashpits, and cesspools, either for the whole or any part of their district.

In parts where the local sanitary authority do not themselves undertake or contract with any person for—

The cleansing of footways and pavements adjoining any premises ;

The removal of refuse from any premises ;

The cleansing of privies, ashpits, and cesspools ;—

they may make bye-laws imposing the duty of such cleansing or removal on the occupier of the premises.

The local sanitary authority may also make bye-laws for the prevention of nuisances arising from snow, filth, dust, ashes, and rubbish, within their district, or of the keeping of animals so as to be injurious to the public health. (*Local Government Act* 1858, sect. 32.)

(4.) *House Drainage, Purification, etc.*—The local sanitary authority must see and provide that all drains, and the water-closets, privies, cesspools, and ashpits, within their district, are constructed and kept so as not to be a nuisance or injurious to health ; and their surveyor may, by their written authority (to be granted upon the written application of any person showing that the drain, water-closet, etc., in respect of which application is made, is a nuisance or injurious to health, but not otherwise), and after twenty-four hours' notice in writing, or, in case of emergency, without notice, to the occupier of the premises to which the drain, water-closet, etc., is attached or belongs, enter the premises, with or without assistants, and cause the ground to be opened, and examine and lay open the drain, etc. If it be found in good order and condition, he is to cause the same to be closed, and all damage to be made good as soon as possible, at the expense of the local authority ; if, on the other hand, it be found not to be in proper order and condition, the owner or occupier is bound, under penalties, to make such alteration and amendment, forthwith and within reasonable time, as may be deemed necessary. (*Public Health Act* 1848, sect. 54.)

No house can be erected, or, if it has been pulled down to or below the ground-floor, rebuilt, nor occupied, until a covered drain or drains shall have been constructed in such manner as, upon the report of the surveyor, shall appear to be necessary and sufficient. If the sea, or a sewer of the local authority, or a sewer which they are entitled to use, be within one hundred feet of any part of the site of the house to be built or rebuilt, the drains to be constructed must lead from and communicate with such one of those means of drainage as the local authority may direct; if, however, no such means of drainage be within that distance, then the drains must be made to communicate with and be emptied into such covered cesspool or other place, not being under any house, and not being within such distance of any house, as the local authority may direct.

If at any time, upon the report of the surveyor, it appear to the local authority that any house, whether built before or after the Act is applied to the district in which it is situate, is without any drain, or without such drain or drains communicating with the sea or sewer as may be sufficient, the owner or occupier is bound to drain under the conditions aforesaid, and to the satisfaction of the local authority. (*Public Health Act* 1848, sect. 49.)

Houses cannot be erected or rebuilt when pulled down to or below the ground-floor, without a sufficient water-closet or privy, and an ashpit, furnished with proper doors and coverings; and if at any time, upon the report of the surveyor, it appear to the local authority that any house, whether built before or after the time when the Act is applied to the district in which it is situate, is without a sufficient water-closet or privy and an ashpit, the owner or occupier is bound forthwith, and within reasonable time, to provide the same, and in such manner as will be satisfactory to the local authority. Where, however, a water-closet or privy is used in common by the inmates of two or more houses, or if in the opinion of the local authority a water-closet or privy may be so used, the local authority need not require them to be provided for each house separately from the other. (*Public Health Act* 1848, sect. 51.)

For the purposes of the Public Health Act, 1848, the word "house" includes schools, factories, and other buildings, in which more than twenty persons are employed at one time. (*Sect.* 2.)

Any enactment of any Act of Parliament in force in any place requiring the construction of a water-closet, shall, with the

approval of the local authority, be satisfied by the construction of an earth-closet, or other place for the deodorisation of fæcal matter, made and used in accordance with any regulation from time to time issued by the local authority.

The local authority may themselves construct, or require to be constructed, earth-closets or other such places as aforesaid, in all cases where, under any enactment in force, they might construct water-closets or privies, or require the same to be constructed, with this restriction, that no person shall be required to construct an earth-closet or other place as aforesaid, in any house instead of a water-closet, if he prefer to comply with the provisions of the enactment requiring the construction of a water-closet, and if a supply of water for other purposes is furnished to such house; and that no person shall be put to greater expense in constructing an earth-closet or other such place than he would be in constructing a water-closet or privy. (*Sanitary Amendment Act* 1868, sect. 7.)

If at any time it appear to the local authority, upon the report of the surveyor, that any house is used, or intended to be used, as a factory or building, in which persons of both sexes and above twenty in number are employed, or intended to be employed, at any time, in any manufacture, trade, or business, the local authority may, by notice in writing to the owner or occupier, require, within a time to be specified by the notice, to be constructed a sufficient number of water-closets or privies for the separate use of each sex. (*Public Health Act* 1848, sect. 52.)

The local sanitary authority may, if they think fit, provide and maintain, in proper and convenient situations, water-closets, privies, and other similar conveniences for public accommodation, and defray the necessary expenses out of the district rates. (*Public Health Act* 1848, sect. 57.)

If, upon the certificate of the medical officer of health, it appear to the local authority that any house, or part of it, is in such a filthy or unwholesome condition that the health of any person is endangered thereby, or that the whitewashing, cleansing, or purifying of any house, or any part of it, would tend to check infectious or contagious disease, the local authority are to give notice in writing to the owner or occupier to whitewash, cleanse, or purify the house, or part of it, as the case may require. Failing compliance, the owner or occupier is liable to penalty, and the local authority may themselves undertake, or cause to

be undertaken, the whitewashing, etc., at the expense of the owner or occupier. (*Public Health Act* 1848, sect. 60.)

In a district containing 10,000 or more persons, and where the Local Government Acts are in force, if the officer of health find that any premises therein are in a condition or state dangerous to health so as to be unfit for human habitation, he shall report thereon to the local sanitary authority. (*Artizans' and Labourers' Dwellings Act* 1868, sect. 5.)

(5.) *Paving, Lighting, and Improving Streets.*—All present and future streets, being, or which at any time become, highways within any district, shall rest in and be under the management and control of the local sanitary authority, who shall from time to time cause all such streets to be levelled, paved, flagged, channelled, altered, and repaired, as when occasion may require. In case any present or future street, or any part thereof, not being a highway repairable by the inhabitants at large, be not sewered, levelled, paved, flagged, and channelled, to the satisfaction of the local authority, they may, by notice in writing to the respective owners or occupiers of the premises fronting, adjoining, or abutting upon such parts thereof as may require to be sewered, levelled, etc., require them to sewer, level, etc., such street, or part thereof, within a time to be specified in the notice. (*Public Health Act* 1848, sect. 68.)

The local authority may purchase any premises for the purposes of widening, opening, enlarging, or otherwise improving any street. (*Public Health Act* 1848, sect. 73.)

(6.) *Public Pleasure-grounds.*—The local authority may provide, maintain, lay out, plant, and improve premises for the purpose of being used as public walks or pleasure-grounds, and support or contribute towards any premises provided by any person for that purpose. (*Public Health Act* 1848, sect. 74.)

(7.) *Water-supply.*—The local sanitary authority may provide their district with such a supply of water as may be proper and sufficient for the purposes of the Public Health Act, and for private use to the extent required by the Act. For any or all of those purposes they may contract with any person, or purchase, take upon lease, hire, construct, lay down, maintain such waterworks, and do and execute all such works as may be necessary and proper. (*Public Health Act* 1848, sect. 75.)

The waterworks here referred to may either be streams, springs, wells, pumps, reservoirs, cisterns, tanks, aqueducts, cuts,

sluices, mains, pipes, culverts, engines, and all machinery, lands, buildings, and things, for supplying water, also the stock in trade of any waterworks company.

Any pollutions of the water-supply, whether derived from streams, springs, wells, etc., is prohibited and punishable by law if the nuisance be not forthwith abated. (*Public Health Act* 1848, sect. 78, 79, 80.)

(8.) *Regulation of Buildings.*—Every local sanitary authority may make bye-laws with respect to the following matters; that is to say—

(*a*) With respect to the level, width, and construction of new streets, and the provision for the sewerage of such streets.

(*b*) With respect to the structure of walls of new buildings, for securing stability and the prevention of fires.

(*c*) With respect to the sufficiency of the space about buildings, to secure a free circulation of air, and with respect to the ventilation of buildings.

(*d*) With respect to the drainage of buildings, to water-closets, privies, ashpits, cesspools, in connection with buildings, and to the closing of buildings unfit for human habitation, and to prohibition of their use for human habitation. (*Local Government Act* 1858, sect. 34.)

(9.) *Offensive Trades.*—The business of a blood-boiler, bone-boiler, fellmonger, slaughterer of cattle, horses, or animals of any description, soap-boiler, tallow-melter, tripe-boiler, or other noxious or offensive business, trade, or manufacture, is not to be newly established in any building or place after the Public Health Act is applied to the district, without consent of the local sanitary authority. The local sanitary authority are also empowered to make bye-laws with respect to any such business newly established as they may think necessary and proper, in order to prevent or diminish any noxious or injurious effects of such businesses. (*Public Health Act* 1848, sect. 64.)

(10.) *Prevention of Smoke.*—(See *ante*, page 345.)

(11.) *Bye-laws.*—Under the Local Government Acts, local sanitary authorities have power to make bye-laws, but they are of no effect unless they are authorised by the Acts and are confirmed by the Local Government Board. When they are so confirmed they have the same force within their limits, and with respect to the persons upon whom they lawfully operate, as an Act of Parliament has upon the subjects at large.

Most of the matters concerning which local sanitary authorities are empowered to make bye-laws have already been enumerated, and need not be again repeated; but as the health officer will have to advise concerning the framing of the great majority of them, the following synopsis of subjects to which they apply may be given:—

(*a*) The general transaction and management of the business of the sanitary authority.

(*b*) The duties, etc., of the several officers and servants of the sanitary authority.

(*c*) The prevention of noxious or injurious effects of businesses newly established in the district. (See *ante*, page 358.)

(*d*) The decent and economical interment of any corpse which may have been received into any rooms or premises provided by the local sanitary authority for the reception of corpses previously to interment.

(*e*) Imposing the duty of cleansing footway and pavements adjoining any premises, privies, ashpits, and cesspools, and the removal of refuse from any premises. (See *ante*, page 354.)

(*f*) For the prevention of nuisances arising from snow, filth, dust, etc. (See *ante*, page 354.)

(*g*) With respect to the construction of new streets, houses, etc. (See *ante*, page 358.)

(*h*) For regulating the licensing and inspection of slaughter-houses and knackers' yards; preventing cruelty to animals therein; for keeping them in a cleanly and proper state; for removing filth from them, and requiring them to be supplied with a sufficient supply of water.

(*i*) For regulating the number of lodgers, and for promoting cleanliness and ventilation in lodging-houses, and the inspection of such houses. (See *ante*, p. 351, and Chapter XIV.)

(*j*) For the regulation of hackney carriages, etc.

(*k*) For licensing and regulating horses, ponies, etc., standing for hire, and fixing the rates of hire for pleasure-boats, etc.

(*l*) For the preservation and regulation of all burial-grounds within their limits when the local board is also the burial board of the district.

(*m*) For the removal to any hospital to which the local sanitary authority is entitled to remove patients, and for keeping in such hospital so long as may be necessary, any persons brought within their district by any ship or boat who are infected with a

dangerous and infectious disorder; and they may, by such rules impose any penalty not exceeding five pounds on any person committing any offence against the same. (*Sanitary Act* 1866, sect. 29.)

8. *Diseases Prevention Act* 1855.—Whenever any part of England appears to be threatened with, or is affected by, any formidable epidemic, endemic, or contagious disease, the Local Government Board may, by order or orders to be by them from time to time made, direct that the provisions of this Act for the prevention of diseases be put in force in England, or in such parts thereof as in the order or orders respectively may be expressed. The order so made is to be in force for six calendar months, or for such shorter period as shall be expressed in it, and the order may at any time be revoked or renewed in like manner. (*Sect.* 5.)

From time to time after the issuing of any such order as aforesaid, and whilst the same continues in force, the Local Government Board may issue directions and regulations as the said Board may think fit—

For the speedy interment of the dead;

For house to house visitation;

For the dispensing of medicines, guarding against the spread of disease, and affording to persons afflicted by or threatened with such epidemic, endemic, or contagious diseases, such medical aid and accommodation as may be required.

And from time to time, in like manner, may revoke, renew, and alter any such regulations as to the said board appears expedient. (*Sect.* 6.)

The sanitary authority shall superintend and see to the execution of such directions (*sect.* 8), and they or their officers shall have full power of entry for the purposes of the Act. (*Sect.* 4.)

9. With respect to *epidemics of smallpox*, the following *Memoranda* issued by the Privy Council may be quoted. (See *First Report of Local Government Board*, 1871-72.)

"By vaccination in infancy, if thoroughly well performed and successful, most people are completely insured, for their whole lifetime, against an attack of smallpox; and in the proportionately few cases where the protection is less complete, smallpox, if it be caught, will, in consequence of the vaccination, generally be so mild a disease as not to threaten death or disfigurement. If, however, the vaccination in early life have been but imperfectly performed, or have from any other cause been but

imperfectly successful, the protection against smallpox is much less satisfactory ; neither lasting so long, nor while it lasts being nearly so complete, as the protection which first-rate vaccination gives. Hitherto, unfortunately, there has always been a very large quantity of imperfect vaccination ; and in consequence the population always contains very many persons who, though nominally vaccinated and believing themselves to be protected against smallpox, are really liable to infection, and may in some cases contract as severe forms of smallpox as if they had never been vaccinated. Partly because of the existence of this large number of imperfectly vaccinated persons, and partly because also even the best infantine vaccination sometimes, in process of time, loses more or less of its effect, it is advisable that *all persons who have been vaccinated in infancy should, as they approach adult life, undergo* RE-VACCINATION. Generally speaking, the best time of life for re-vaccination is about the time when growth is completing itself, say from 15 to 18 years of age ; and persons in that period of life ought not to delay their re-vaccination till times when there shall be special alarm of smallpox. In proportion, however, as there is prevalence of smallpox in any neighbourhood, or as individuals are from personal circumstances likely to meet chances of infection, the age of 15 need not be waited for ; especially not by young persons whose marks of previous vaccination are unsatisfactory. *In circumstances of special danger, every one past childhood, on whom re-vaccination has not before been successfully performed, ought without delay to be re-vaccinated.*

"Re-vaccination, once properly and successfully performed, *does not appear ever to require repetition.* The nurses and other servants of the Smallpox Hospital, when they enter the service, are invariably submitted to vaccination, which in their case generally is re-vaccination, and is never afterwards repeated ; and so perfect is the protection, that though the nurses live in the closest and most constant attendance on smallpox patients, and though also the other servants are in various ways exposed to special chances of infection, the resident surgeon of the hospital, during his thirty-four years of office there, has never known smallpox affect any one of these nurses or servants.

" Legal provisions for re-vaccination are made in the 8th Section of the Vaccination Act 1867, and in Section IV. of the Regulations which the Lords of the Council, under authority of the Act, issued in their Order of February 18th, 1868. Under

these provisions, *Re-vaccination is now performed by all public vaccinators at their respective vaccinating stations;* and, so far as is not inconsistent with the more imperative claims for primary vaccination, *any person who ought to be re-vaccinated may, on applying to the public station of the district in which he resides, obtain re-vaccination at the public expense.*

"Where medical practitioners, not being public vaccinators, and not having otherwise in their practice cases for primary vaccination, are called upon to re-vaccinate on considerable scale (as in hospitals, commercial establishments, schools, and even large households), they would generally find it best to make direct application for assistance to the public vaccinator of the district in which they have to act; with whose assistance they may commonly find it in their power to arrange with the parents of children recently vaccinated at the public station, that some of such children shall at the proper time be taken to places where private re-vaccinations have to be performed, so as to furnish from arm to arm any required quantity of lymph. Generally, too, any private medical practitioner who, from any cause, desires to obtain extraordinary supplies of lymph, will most easily attain his object by applying to the public vaccinator of the district in which he resides. And as public vaccinators, appointed under the Vaccination Act 1867 are of course free to accept payment for any extra-official work which they may be willing to undertake, private practitioners would probably have no difficulty in obtaining, by voluntary agreement, the assistance of some of these officers as collectors of lymph for private re-vaccination.

"It is important for the public to observe that re-vaccination on a large scale is not easily conducted unless in a thoroughly systematic manner, and that individual difficulties in finding lymph for re-vaccination are inseparable from the too general practice of deferring re-vaccination to periods of panic, instead of having it proceed, as it should, regularly and uniformly, in proportion as successive numbers of population reach the proper age for its performance."

By an Order dated July 29th, 1871, all vaccinations and inspections under contract shall be performed in accordance with the "Instructions for Vaccinators under Contract" hereto annexed :—

"(1.) Except so far as immediate danger of smallpox may require, vaccinate only subjects who are in good health. As

regards infants, ascertain that there is not any febrile state, nor any irritation of the bowels, nor any unhealthy state of skin ; especially no chafing or eczema behind the ears, or in the groin, or elsewhere in folds of skin. Do not, except of necessity, vaccinate in cases where there has been recent exposure to the infection of measles or scarlatina, nor where erysipelas is prevailing in or about the place of residence.

"(2.) In all ordinary cases of primary vaccination, if you vaccinate by separate punctures, make such punctures as will produce at least four separate good-sized vesicles, not less than half an inch from one another ; or, if you vaccinate otherwise than by separate punctures, take care to produce local effects equal to those just mentioned.

"(3.) Direct care to be taken for keeping the vesicles uninjured during their progress, and for avoiding afterwards the premature removal of the crusts.

"(4.) Enter all cases in your register on the day when you vaccinate them, and with all particulars required in the register up to column 9 inclusive. Enter the results on the day of inspection. Never enter any results which have not been inspected by yourself or your legally-qualified deputy. In cases of primary vaccination, register as "successful" only those cases in which the normal vaccine vesicle has been produced ; in cases of re-vaccination, register as "successful" only those cases in which either vesicles, normal or modified, or papules surrounded by areolæ, have resulted. When the vaccination of an unsuccessful case is repeated, it should be entered as a fresh case in the register.

"(5.) Endeavour to maintain in your district such a succession of cases as will enable you uniformly to vaccinate with liquid lymph directly from arm to arm ; and do not, under ordinary circumstances, adopt any other method of vaccinating. To provide against emergencies, always have in reserve some stored lymph ; —either *dry*, as on thickly-charged ivory points, constantly well protected from damp ; or *liquid*, according to the method of Dr. Husband of Edinburgh, in fine, short, uniformly capillary (not bulbed) tubes, hermetically sealed at both extremities. Lymph, successfully preserved by either of these methods, may be used without definite restriction as to time ; but with all stored lymph caution is necessary, lest in time it have become inert, or otherwise unfit for use. If, in order to vaccinate with recent liquid

lymph, you convey it from case to case otherwise than in hermetically-sealed capillary tubes, do not ever let more than eight hours intervene before it is used.

"(6.) Consider yourself strictly responsible for the quality of whatever lymph you use or furnish for vaccination. Never either use or furnish lymph which has in it any, even the slightest, admixture of blood. In storing lymph, be careful to keep separate the charges obtained from different subjects, and to affix to each set of charges the name, or the number in your register, of the subject from whom the lymph was derived. Keep such note of all supplies of lymph which you use or furnish, as will always enable you, in any case of complaint, to identify the origin of the lymph.

"(7.) Never take lymph from cases of re-vaccination. Take lymph only from subjects who are in good health, and, as far as you can ascertain, of healthy parentage; preferring children whose families are known to you, and who have elder brothers or sisters of undoubtful healthiness. Always carefully examine the subject as to any existing skin-disease, and especially as to any signs of hereditary syphilis. Take lymph only from well-characterised, uninjured vesicles. Take it (as may be done in all regular cases on the day week after vaccination) at the stage when the vesicles are fully formed and plump, but when there is no perceptible commencement of areola. Open the vesicles with scrupulous care to avoid drawing blood. Take no lymph which, as it issues from the vesicle, is not perfectly clear and transparent, or is at all thin and watery. From such a vesicle as vaccination by puncture commonly produces, do not, under ordinary circumstances, take more lymph than will suffice for the immediate vaccination of five subjects, or for the charging of seven ivory points, or for the filling of three capillary tubes; and from larger or smaller vesicles take only in like proportion to their size. Never squeeze or drain any vesicle. Be careful never to transfer blood from the subject you vaccinate to the subject from whom you take lymph.

"(8.) Scrupulously observe in your inspections every sign which tests the efficiency and purity of your lymph. Note any case wherein the vaccine vesicle is unduly hastened or otherwise irregular in its development, or wherein any undue local irritation arises; and if similar results ensue in other cases vaccinated with the same lymph, desist at once from employing it. Consider that your lymph ought to be changed, if your cases, at the usual

time of inspection on the day week after vaccination, have not, as a rule, their vesicles entirely free from areolæ.

"(9.) Keep in good condition the lancets or other instruments which you use for vaccinating, and do not use them for other surgical operations. When you vaccinate, have water and a napkin at your side, with which invariably to cleanse your instrument after one operation before proceeding to another.

(Signed) JOHN SIMON.

"*N.B.*—Supplies of lymph are furnished to medical practitioners, on personal application, at 3 Parliament Street, London, S.W., between the hours of 12 and 2; or by letter (unstamped) addressed as follows:—

To the Medical Officer of the Privy Council,
3 Parliament Street,
London, S.W.

National Vaccine Establishment."

10. With respect to *quarantine*, it is enacted by the Sanitary Act 1866, sect. 52, as follows:—

Every vessel having on board any person affected with a dangerous or infectious disorder shall be deemed to be within the provisions of the Act of the sixth year of King George the Fourth, chapter seventy-eight, although such vessel has not commenced her voyage, or has come from or is bound for some place in the United Kingdom; and the Lords and others of Her Majesty's Most Honourable Privy Council, or any three or more of them (the Lord President of the Council, or one of Her Majesty's Principal Secretaries of State, being one), may by Order or Orders to be by them from time to time made, make such rules, orders, and regulations as to them shall seem fit, and every such Order shall be certified under the hand of the Clerk in Ordinary in Her Majesty's Privy Council, and shall be published in the London Gazette, and such publication shall be conclusive evidence of such Order to all intents and purposes; and such

Orders shall be binding and be carried into effect as soon as the same shall have been so published, or at such other time as shall be fixed by such Orders, with a view to the treatment of persons affected with cholera, and epidemic, endemic, and contagious disease, and preventing the spread of cholera and such other diseases, as well on the seas, rivers, and waters of the United Kingdom, and on the high seas within three miles of the coasts thereof, as on land ; and to declare and determine by what nuisance authority or authorities such orders, rules, and regulations, shall be enforced and executed ; and any expenses incurred by such nuisance authority or authorities shall be deemed to be expenses incurred by it or them in carrying into effect the Nuisances Removal Acts.

Under the provisions of the above section the following Order in Council was issued July 29th, 1871 :—

Art. (1.) In this Order—

The term "ship" includes vessel or boat.

The term "master" includes the officer or person for the time being in charge or command of a ship.

The term "cholera" includes choleraic diarrhœa.

The term "nuisance authority" has the same meaning as in "The Sanitary Act 1866."

Art. (2.) It shall be lawful for any nuisance (sanitary) authority having reason to believe that any ship arriving in its district comes from a place infected with cholera, to visit and examine such ship before it enters any port, or lands any person or thing in the district, for the purpose of ascertaining whether such ship comes within the operation of this Order.

Art. (3.) The master of every ship within the district of a nuisance (sanitary) authority, having on board any person affected with cholera, or the body of any person dead of cholera, or anything infected with, or that has been exposed to the infection of cholera, shall, as long as the ship is within such district, moor, anchor, or place her in such position as from time to time the nuisance authority directs.

Art. (4.) No person shall land from any such ship until the examination hereinafter mentioned has been made.

Art. (5.) The nuisance authority shall, immediately on the arrival of such a ship, cause all persons on board of the same to be examined by a legally-qualified medical practioner (health officer), and shall permit all persons who shall not be certified by him to be suffering from cholera to land immediately.

Art. (6.) All persons certified by the examiner to be suffering from cholera shall be dealt with under any rules that may have been made by the nuisance authority under the 29th section of the Sanitary Act 1866 (see *ante*, page 359); or, where no such rules have been made, shall be removed, if their condition admits of it, to some hospital or place to be designated for such purpose by the nuisance authority, and no person so removed shall quit such hospital or place, until some physician or surgeon shall have certified that such person is free from the said disease.

Art. (7.) In the event of any death from cholera taking place on board of such vessel, the body shall be taken out to sea and committed to the deep, properly loaded to prevent its rising.

Art. (8.) The clothing and bedding of all persons who shall have died, or had an attack of cholera on board such vessel, shall be disinfected, or (if necessary) destroyed, under the direction of the nuisance authority.

Art. (9.) The ship, and any articles therein, which may be infected with cholera, shall be disinfected by the nuisance authority.

Art. (10.) Every person obstructing the nuisance authority in carrying this order into effect, or otherwise offending against this order, shall be liable, on summary conviction, to a penalty not exceeding twenty pounds.

II.

1. Comparison of the metrical with the common English measures, as regards capacity and weight, from tables arranged by Mr. Warren de la Rue, F.R.S.

MEASURES OF CAPACITY.	In Cubic Inches.	In Cubic Feet = 1728 Cubic Inches.	In Pints = 34·65923 Cubic Inches.
Millilitre, or cubic centimetre . . .	0·061027	0·0000353	0·001761
Centilitre, or 10 cubic centimetres	0·610271	0·0003532	0·017608
Decilitre, or 100 cubic centimetres	6·102705	0·0035317	0·176077
Litre, or cubic decimetre	61·027052	0·0353166	1·760773
Decalitre, or centistere	610·270515	0·3531658	17·607734
Hectolitre, or decistere	6102·705152	3·5316581	176·077341
Kilolitre, or stere, or cubic metre .	61027·051519	35·3165807	1760·775314
Myriolitre, or decastere	610270·515194	353·1658074	17607·734140

1 cub. in. = 16·3861759 cub. centimetres. 1 cub. ft. = 28·3153119 cub. decimetres.
1 fluid oz. = 28·4 c.c. 1 gallon = 4·543457969 litres. 1 quart = 1·136 litre.

MEASURES OF WEIGHT.	In English Grains.	In Troy Ounces = 480 Grains.	In Avoirdupois Lbs. = 7000 Grains.
Milligramme	0·015432	0·000032	0·0000022
Centigramme	0·154323	0·000322	0·0000220
Decigramme	1·543235	0·003215	0·0002205
Gramme	15·432349	0·032151	0·0022046
Decagramme	154·323488	0·321507	0·0220462
Hectogramme	1543·234880	3·215073	0·2204621
Kilogramme	15432·348800	32·150727	2·2046213
Myriogramme	154323·488000	321·507267	22·0462126

1 Grain = 0·064798950 Gramme. 1 lb. Avd. = 0·45359265 Kilogr.
1 Troy oz. = 31·103496 Gramme. 1 Cwt. = 50·80237689 Kilogr.

2. For the convenience of medical officers of health, the following price-list of apparatus and reagents, mentioned in various parts of the work, has been supplied by Messrs. Griffin and Sons, manufacturers of chemical and philosophical apparatus,

22 Garrick Street, Covent Garden, London, W.C. The various articles are priced separately, so that purchasers may select such of them as they may require. The numbers on the left hand margin refer to those given in Messrs. Griffin and Sons' very useful catalogue, known as *Chemical Handicraft*. The prices quoted are subject to an advance of 10 per cent :—

For the Examination of Air.

		£	s.	d.
	1 Set of Gramme Weights, 5, 2, 1, 1, to 1 Milligramme	£1	2	0
429	1 Balance for do.	1	16	0
2791/8	1-1 Litre Measure graduated into c.c.	0	9	0
1535/46	4 Glass Jars to hold 5000 c.c. each	1	2	0
	8 India-rubber Caps for ditto (double set)	1	16	0
2794/5	1 Tall narrow Glass, marked to measure 30 and 60 c.c.	0	2	3
2688/9	1 Mohr's Burette 50 c.c. graduated into 1-10th	0	5	9
2694/h	1 Support for ditto (Mahogany)	0	5	0
4593	1 Bellows Pump with long nozzle (length sufficient to reach the bottom of the jars)	0	4	6
2798 c	2 Mixing Jars 1 Pint	0	2	6
115	6 Glass Stirrers for ditto	0	0	9
	4 oz. Turmeric Paper	0	0	6
1626/6	1 Box of Filter Papers	0	2	0
	1 Glass Funnel 4″	0	0	4
	4 oz Pure Cryst. Oxalic Acid 1/. Bottle for ditto 4d.	0	1	4
	1 lb. Calcium Hydrate (for making lime water) 9d. Bottle 4d.	0	1	1
	Rough deal case (say)	0	15	0
		£8	6	0
	10 per cent advance	0	16	8
	(About)	£9	2	8
	1 Common wet and dry bulb Thermometer Fahr. (Mason's)	£0	9	0

For the Qualitative Examination of Water.

		£	s.	d.
	2 Tall colourless glass Cylinders 2 ft. high 1″ diam.	0	10	0
1401	1 Wide mouth colourless glass Flask to hold about 1000 c.c.	0	1	0

		£	s.	d.
1743	1 Nest Porcelain Evaporating Basins, 2, 4, 8, and 16 oz.	£0	3	6
1323	1 Porcelain Crucible $2\frac{1}{4}''$ diam.	0	10	0
2410	1 Set (6) Clark's Test Glasses	0	1	6
2011	Apparatus for making sulphuretted hydrogen water (pint)	0	5	0
2446 b	6 oz. Sol. Caustic Potash	0	2	1
	2 ,, ,, Gold Bichloride	0	8	5
	6 ,, ,, Ammonium Oxalate	0	1	10
	6 ,, ,, Barium Nitrate	0	1	4
	6 ,, ,, Silver Nitrate	0	3	4
	6 ,, ,, Nessler's Test Solution (about)	0	2	5
	6 ,, ,, Ammonia, strong	0	1	4
	6 ,, ,, Acetic Acid	0	2	4
	6 ,, ,, Nitric Acid, dilute	0	1	10
	6 ,, ,, Sulphuric Acid, pure conctd.	0	2	1
	6 ,, ,, Hydrochloric Acid, dilute	0	1	7
	2 ,, Potassium Iodide	0	1	4
	2 ,, Potassium Permanganate	0	1	4
	6 ,, Ferrous Sulphide lumps	0	0	3
	2 ,, ,, Sulphate	0	1	7
	2 ,, Indigo Sol. Sulphate	0	0	11
	Box (say)	0	6	0
	(About)	£3	11	0

For the Examination of Milk.

620	1 Lactometer graduated to test approximately the percentage of adulteration with water (in a case)	£0	3	0
874	1 Tall narrow glass vessel graduated to test percentage of cream (in a case)	0	2	0

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THE END.

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